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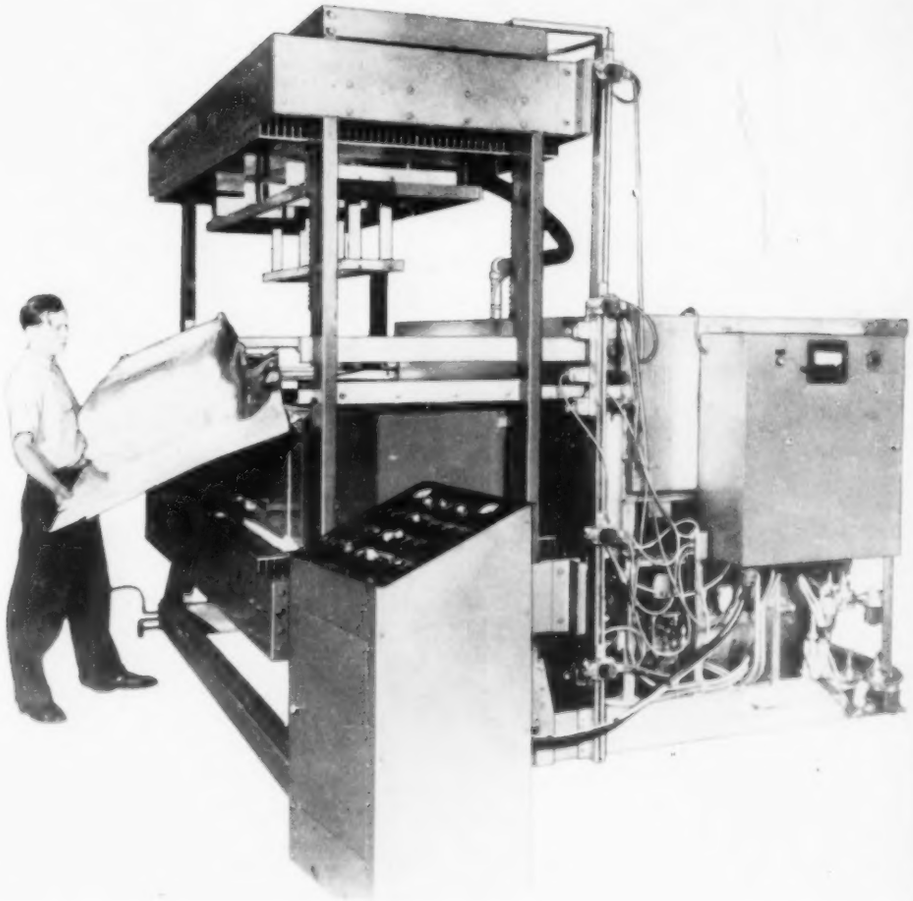
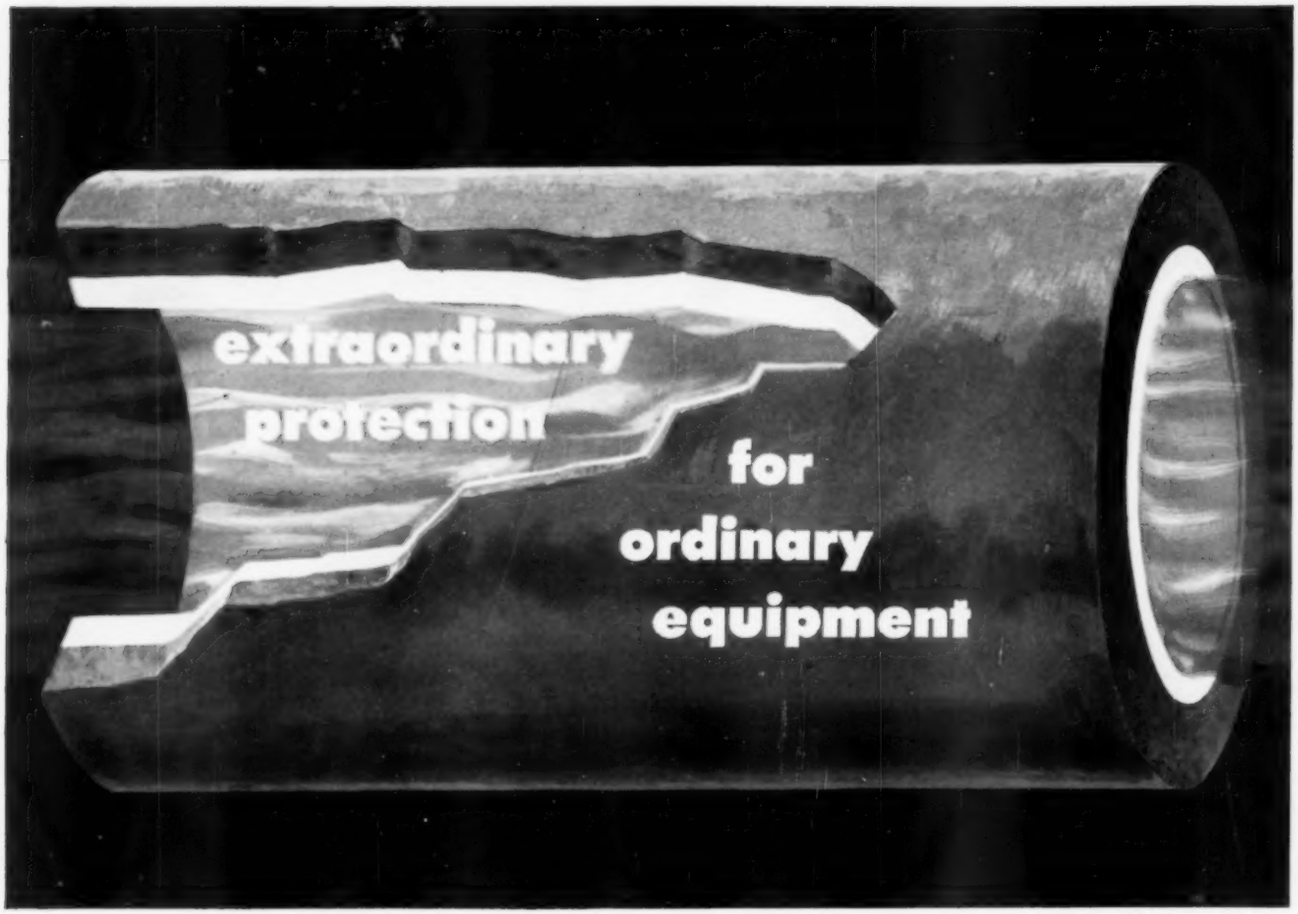
(Story on page 44)



PUBLISHED BY THE SOCIETY OF PLASTICS ENGINEERS, INC.



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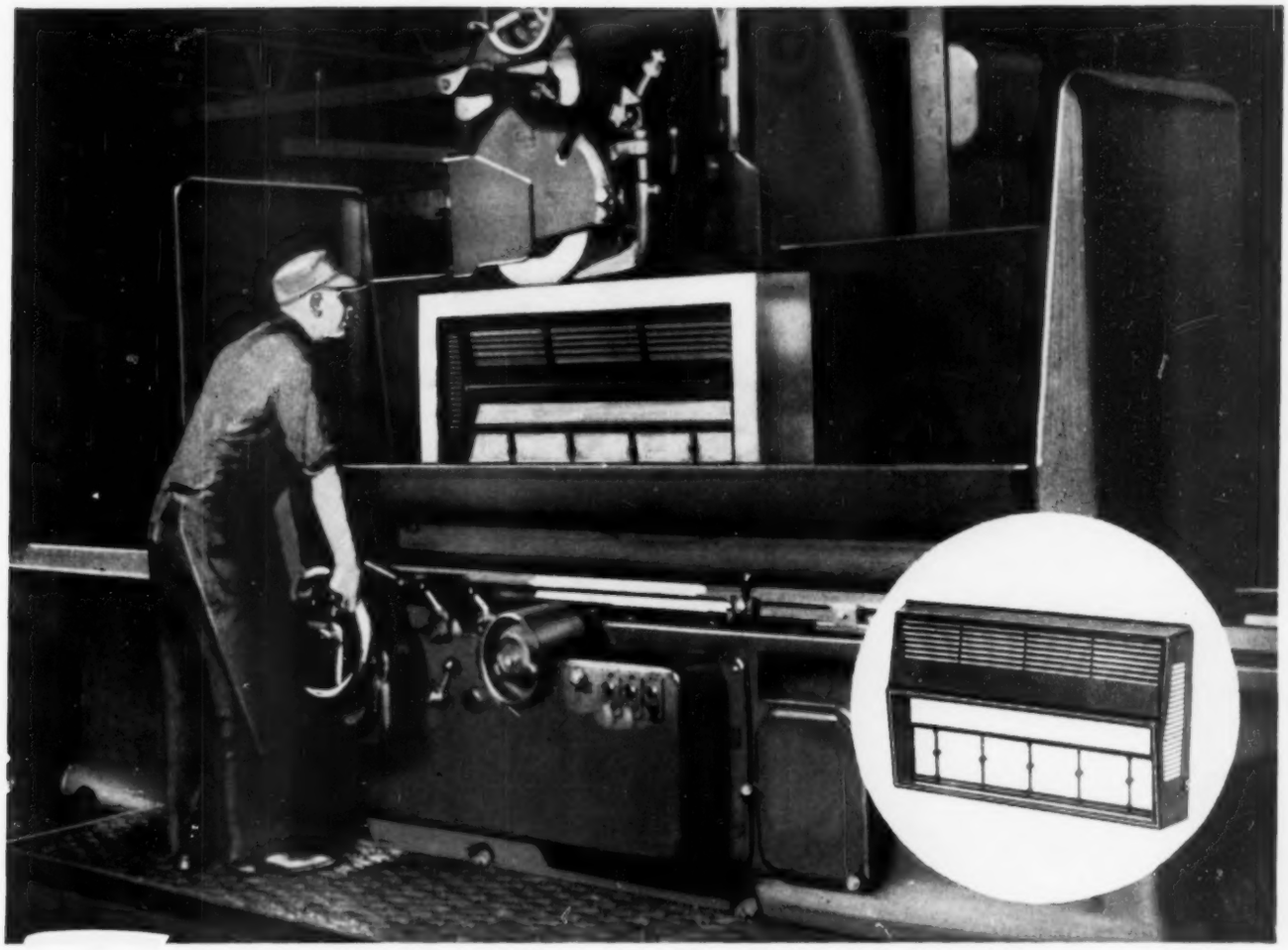

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Vol. 1, No. 6

HEAT SEALING OF FILM

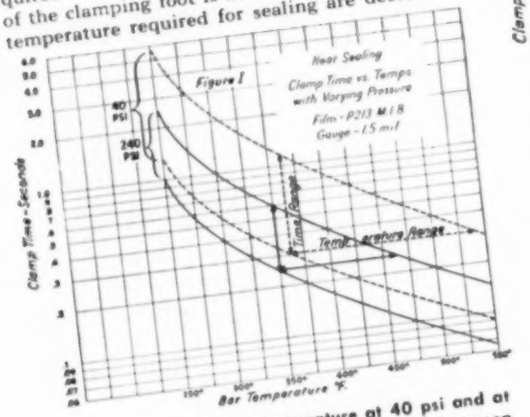
The fabricator of packaging film, who turns out bags and other packages by heat sealing processes, can expect to work more and more with polyethylene in the next few years. The reason: polyethylene is becoming more and more in demand as a packaging material.

It therefore becomes important that the fabricator understand the heat sealing characteristics of polyethylene. In the usual commercial set-up two sets of factors affect heat seal characteristics —

- *The machine factors* — temperature, pressure and time
- *The film factors* — thickness, resin melt index and bag style

Influence of Machine Variables

For any polyethylene film, these relationships apply: As bar temperature goes up, the time required to make a seal goes down. As pressure of the clamping foot is increased, both time and temperature required for sealing are decreased.



Clamp time versus bar temperature at 40 psi and at 240 psi, for a 1½ mil flat bag. The area between the curves represents the temperature range or time range within which satisfactory seals can be obtained. Note that the curves get wider apart at higher temperatures and lower pressures. This means that the fabricator can operate with greater flexibility of machine conditions by working at low pressures and high temperatures.

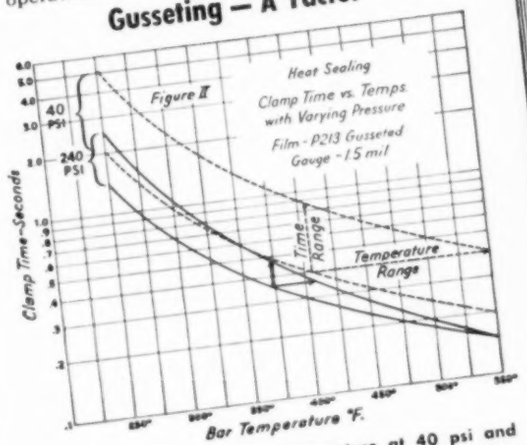
As the machine is operated, heat builds up in the unheated foot. This effect is greatest with long clamp times and can result in a heat rise of as much as 50°F. The fabricator must take this into account as it will narrow his working temperature range.

Influence of Film Variables

Using a thicker film increases the time required to make a seal — about 50% for every mil of added thickness in the 1-5 mil range. If the film thickness in Figure I were 2.5 mils, the whole operating range would be shifted upward by about 50%.

Melt index of the basic resin also affects operation. Going from a high melt index to a low melt index resin tends to widen the operating range in which a seal can be made. The spread occurs at the upper time or temperature limit only — the lower limit remains the same. Going to one half the melt index increases the time range or temperature range for satisfactory operation by about 50%.

Gusseting — A Factor



Clamp time versus bar temperature at 40 psi and 240 psi, for a gusseted bag. Note that the operating range is narrowed, more so at high pressures than at low.

U.S.I. Offers Technical Assistance

U.S.I. makes polyethylene resins for film manufacture, resins such as PETROTHENE® 110 and 210 — tailor made for blown and flat film extrusions, and PETROTHENE® 213 — selected in specific cases for transparency, hand and high production rates.

U.S.I. Technical Service Engineers have studied the behavior of polyethylene film during heat sealing and will be glad to work with film extruders on their particular heat sealing problems. A Technical Bulletin describing in more detail U.S.I.'s laboratory results on heat sealing is available on request.

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SPE JOURNAL

Vol. 12 November, 1956 No. 11

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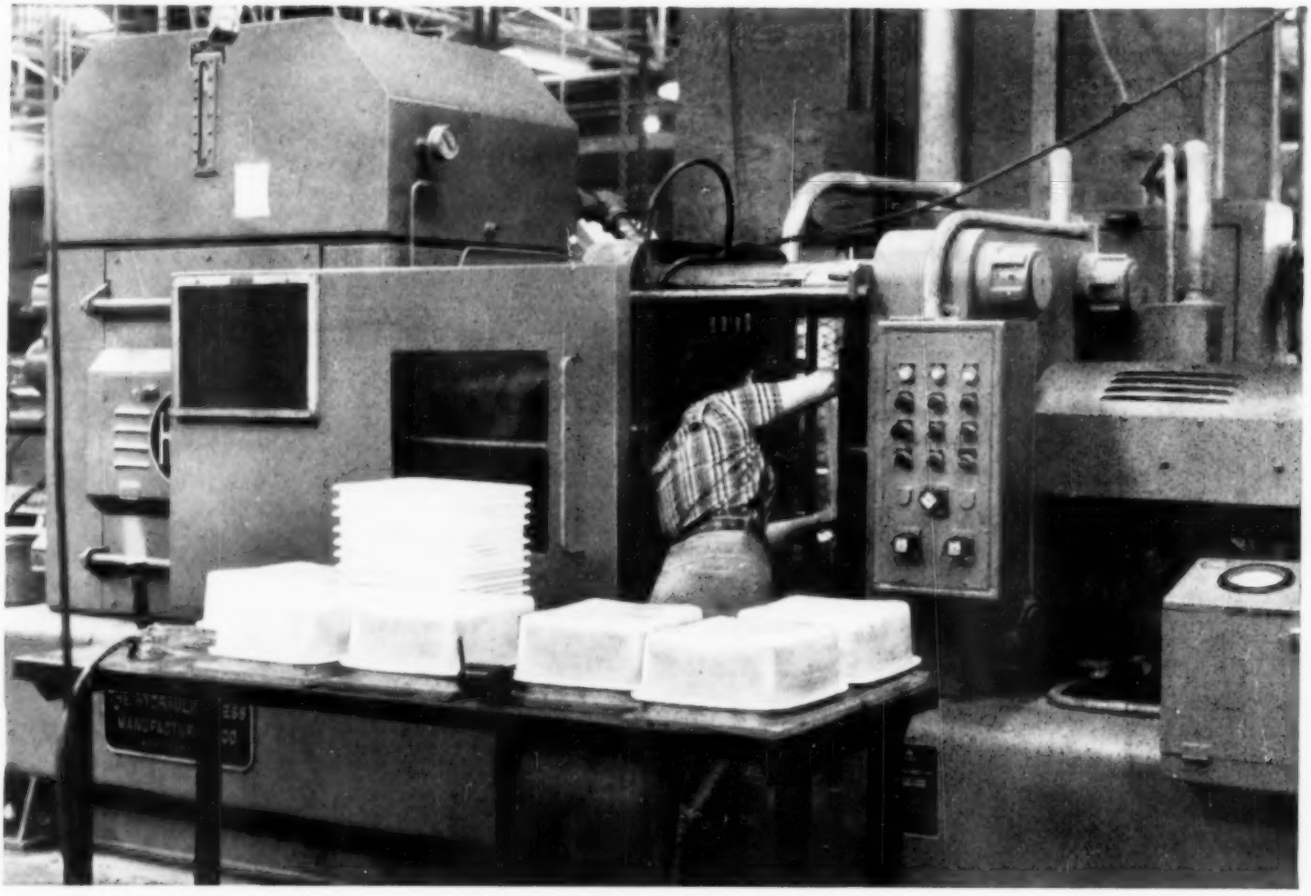
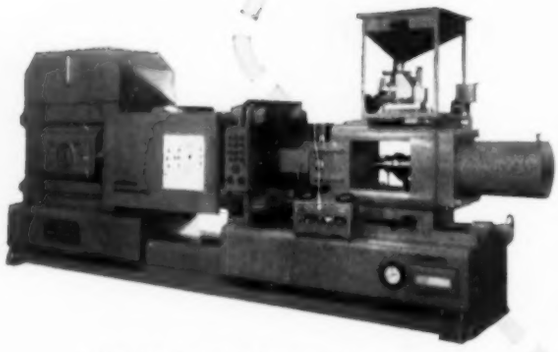


"We have six now with three more on the way"



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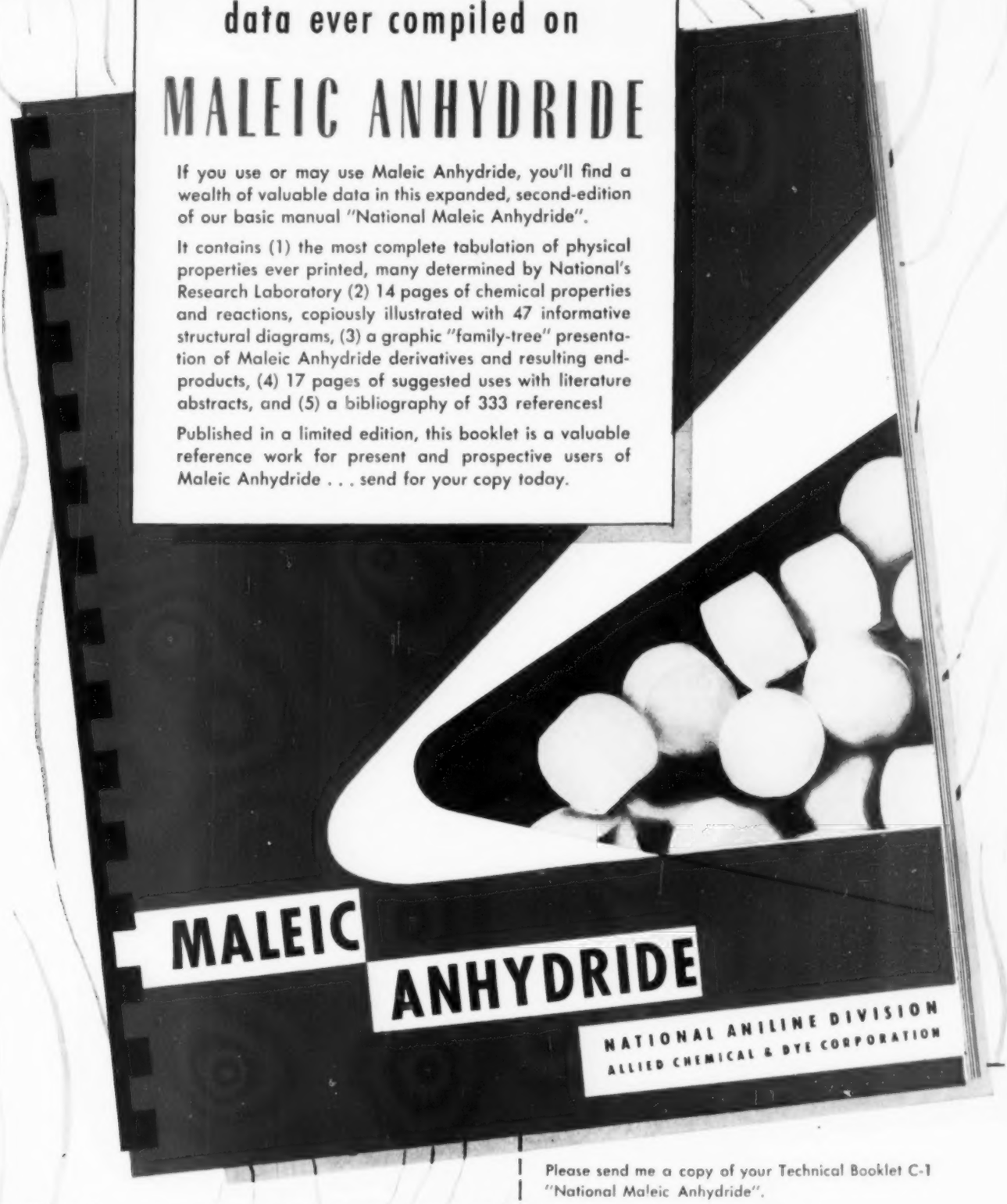

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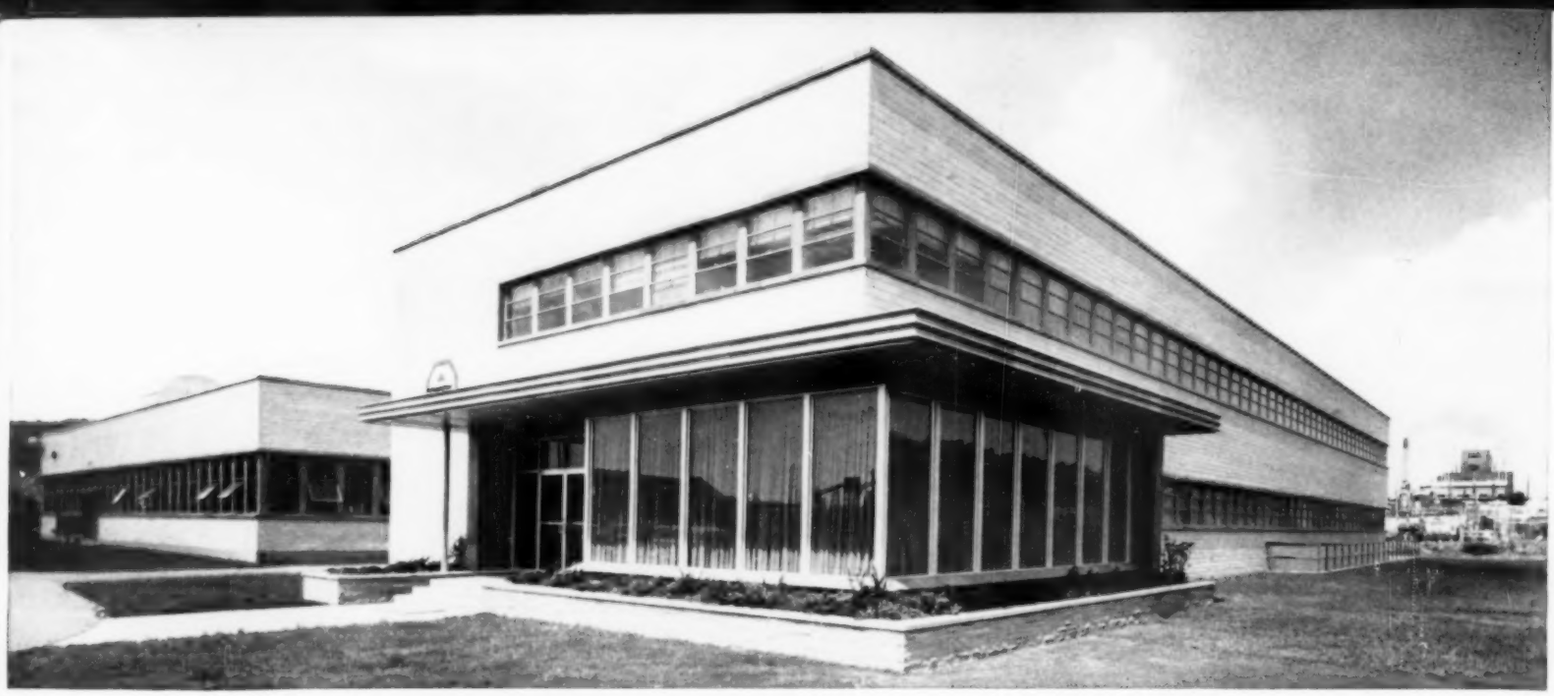

New Koppers Development Laboratory promises **better products through finer plastics**

Here are 45,000 square feet of gleaming, modern laboratories, testing rooms, machine shops and fine equipment. They make up the new Koppers Company Development Laboratory at Kobuta, Pennsylvania.

The new lab was inspired by Koppers long-time belief in the dynamic field of plastics. Koppers feels that, in the coming years, even greater strides will be made by the industry, and plans to make every effort possible to assist the industry in this growth.

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Acrylic Resin

Du Pont LUCITE 140 acrylic resin is now commercially available in a formulation which permits molding temperatures 30° to 50°F. higher than previously possible with any acrylic resin. The new upper molding limit—the maximum temperature to which the molding powder may be heated for the length of time required in normal molding cycles—presents certain advantages in injection-molding operations, such as increased fluidity during processing and increased stability after processing.

All other physical properties are unchanged, as this improvement is in stability of material at molding temperatures rather than in formulation of a completely new resin.

Increased fluidity

A faster molding cycle is possible in some cases due to increased fluidity. The minimum cycle is primarily dependent on melt temperature, as heat in shot must be removed before the part can be ejected. Therefore, the cooling portion of the cycle remains about the same. But greater fluidity in some molds permits shorter injection time.

The greater fluidity also permits smaller gates and consequently less trimming of the molded piece.

Increased stability

The improved formulation shows greater resistance to craze or deformation on application of solvents. And, because it is now possible to mold more intricate shapes with less strain, in some instances there will be an increase in top service temperature for parts molded of LUCITE 140.

Over the entire molding range, this improved LUCITE will provide thicker sections free from bubbles and thinner sections without surface blemishes. The characteristic sparkle and weather resistance are maintained.

Adoption of this new formulation of the proven LUCITE 140 brings improved properties to molder and end user—and increased profits to both, as this formulation is being provided by Du Pont at no increase in price. For further information write to E. I. du Pont de Nemours & Co. (Inc.), Polychemicals Department, Room 4211, Du Pont Building, Wilmington 98, Delaware.

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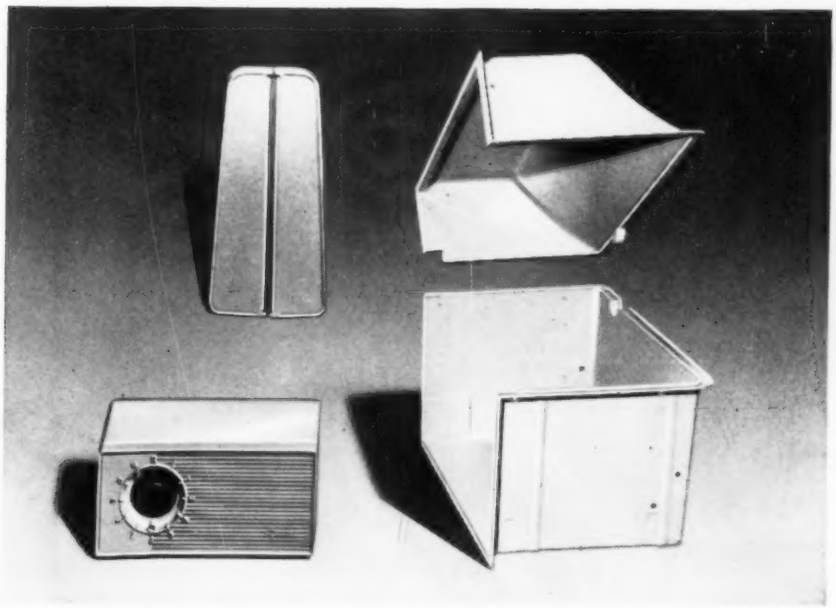
THE IMPORTANCE OF CONTROLLED PRESSURE IN PLASTICS MOLDING



Recent developments in controlling plastics pressure have made it now possible to mold large, complex shapes, such as the radio cabinet, refrigerator liner and luggage end caps.

The disposable cup exemplifies the uniform quality product now demanded of materials and processes in fully automatic, high-speed molding. These cups were molded from Styron 689, a new general purpose formulation with greatly improved properties of easy flow.

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A CONTINUING REPORT

Results of Dow Plastics Technical Service research will appear in these pages from time to time. For a complete summary of Dow products and services, write: THE DOW CHEMICAL COMPANY, Midland, Michigan—Plastics Sales Department PL 429D.

INJECTION MOLDING RESEARCH SHOWS WAY TO BETTER TECHNOLOGY

In the continuing Plastiatrics studies under the direction of Dow Plastics Technical Service, one of the most rewarding areas of investigation for meeting more exacting needs today has been in the control of plastics pressure.

Beginning with the remarkable results of the early "pinpoint gate", considerations for equalizing pressure distribution in the molding system have assumed greater importance. Mechanical aids, such as the "free-flow" and "ball-check" nozzles, were adopted. Thermal studies on the effect of mold heats have made die temperature control units commonplace. Later findings that pressure control is directly related to the accuracy with which granules are fed to the heating cylinder led to the adoption of weigh feeders and pre-plasticizers for top efficiency.

Currently, the heating cylinder itself is a subject of widespread investigation for better conservation of pressure. Studies point to the fact that more efficient designs will greatly improve performance of the molding process. Meanwhile, at Dow the size, shape and treatment of plastic granules to conserve pressure loss have become important considerations in their manufacture. In Styron® (Dow polystyrene) alone four different granulations are offered with or without surface treatments to provide the molder unparalleled versatility in meeting design requirements.

The practical benefits of continuing Plastiatrics studies, such as those on pressure control, result in leadership. In Dow plastics you will find the better quality of materials more meaningful because they are realistically designed to perform for you. Ask for your copy of "Injection Molding Research Today and Tomorrow" or get in touch with your Dow representative for more complete information.

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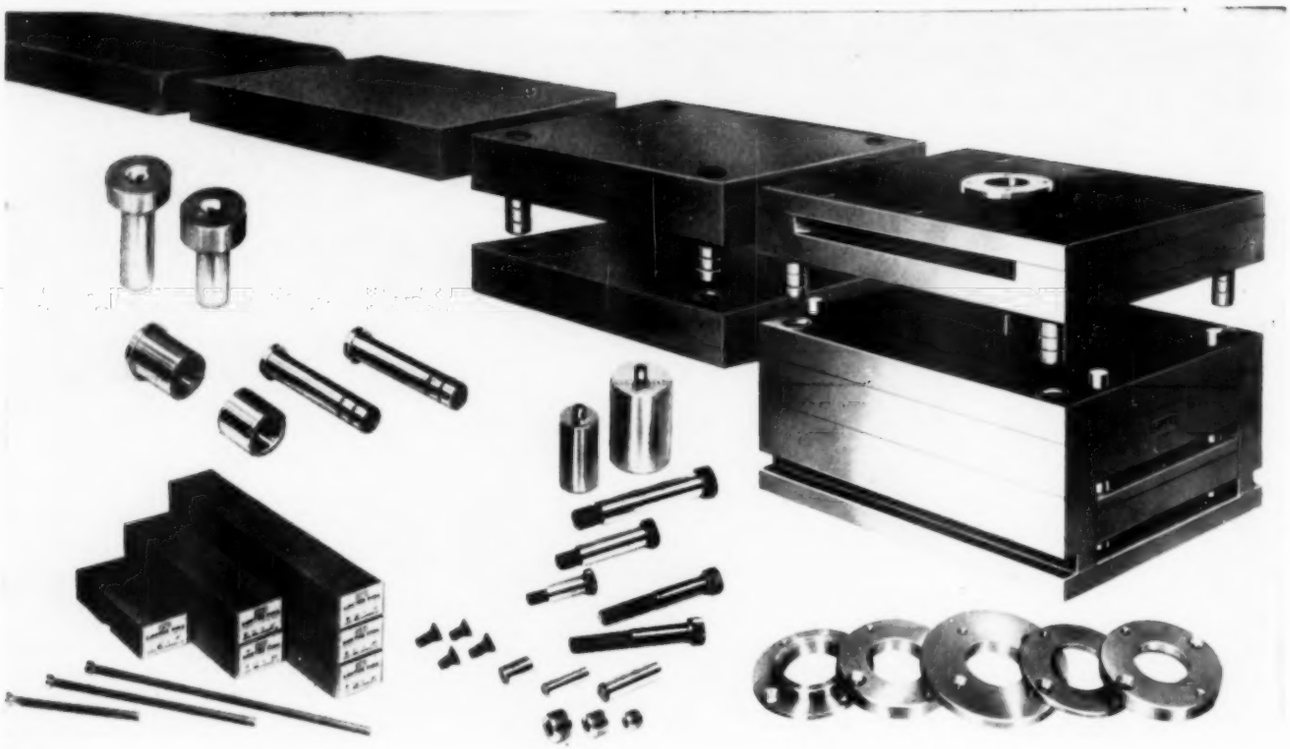

PROGRESS THROUGH STANDARDS

. . . and how DME "helped"

The history of economy in modern business has been directly related to the history of Standardization. One of the major elements affecting the economic production of finished plastic parts is the high initial cost of the mold. A progressive step in reducing mold cost, without sacrificing the high quality required, has been successfully achieved through Standardization.

When D-M-E originated Standard Mold Bases and their component parts in 1942, it provided the answer to the rapidly growing demand for high quality molds that would maintain and promote the economic advantages of plastic parts.

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Today D-M-E produces twenty-eight different sizes of Standard Mold Bases, from 9" x 8" to 23¾" x 35½", in either D-M-E No. 1 or No. 2 Steel, with a wide range of cavity plate thicknesses to satisfy the diversified demands required. In addition, over 2,000 finished component parts of the same high quality are available to provide additional savings in service as well as in the product.

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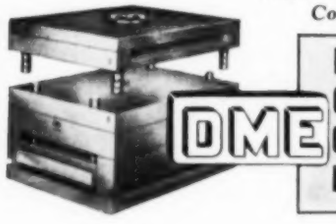

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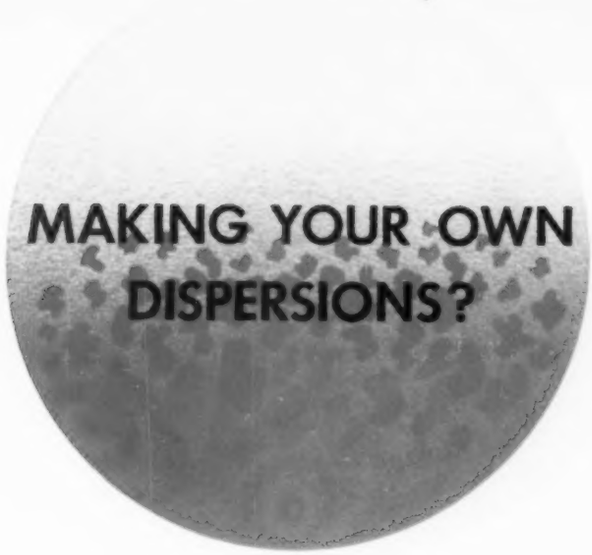

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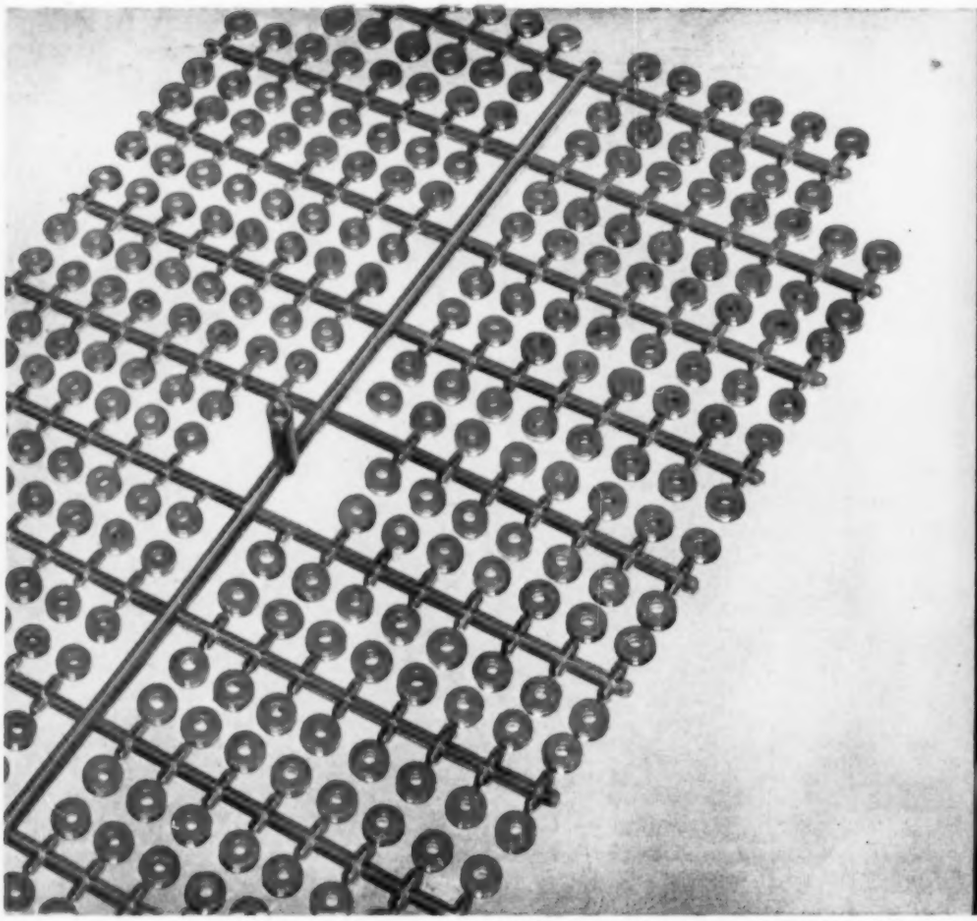

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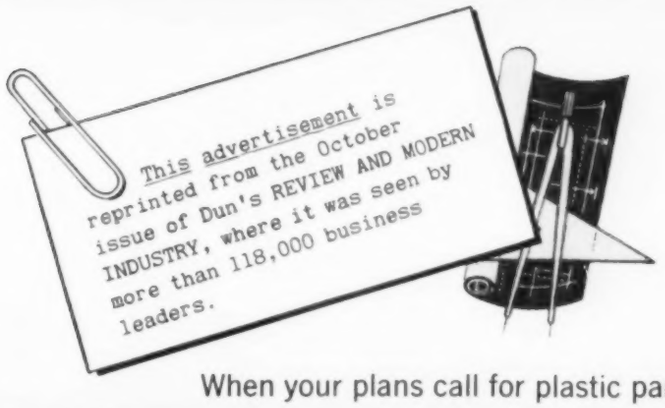
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Inspired by the materials at hand, the artisans of other ages fashioned masterpieces of glass and steel, wood and silver.

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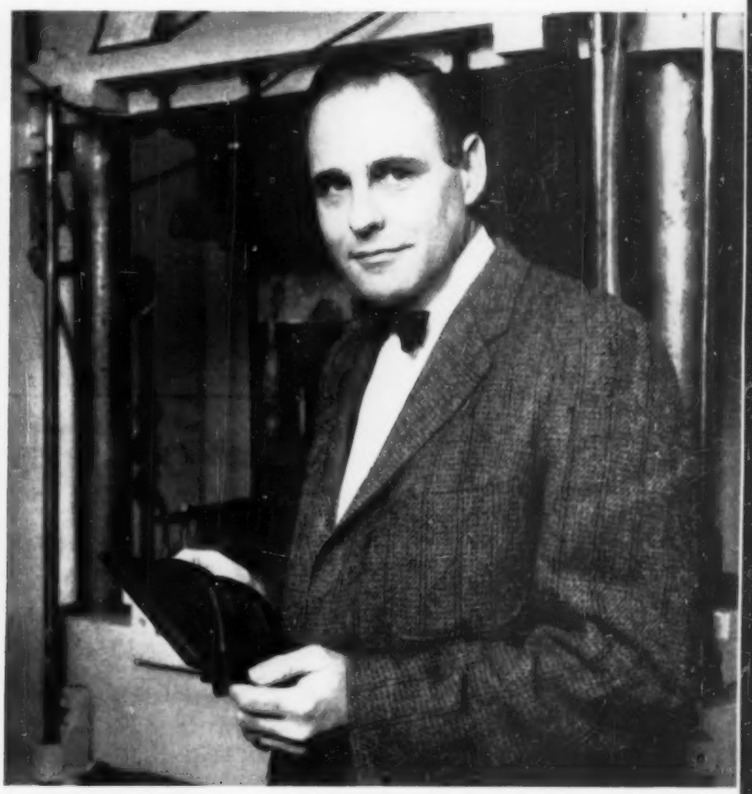
Two of these "20th century craftsmen" are pictured on this page. Monsanto, a major producer of high-quality plastic materials, salutes these men who are helping to mold America's tomorrow.

When your plans call for plastic parts or products, consult an expert custom molder

Smith E. Powell, Michigan Panelyte Molded Plastics, Inc., Dexter, Mich. Mr. Powell got his start in plastics at Reynolds Molded Plastics, Jackson, Mich., in 1923, and has been Superintendent of Compression Molding at Michigan Panelyte for 16 years. He has had first hand experience in tool and die making, hydraulics, materials, processing and manufacture. Under Mr. Powell's direction, 32 molding machines (ranging from 50 to 500 ton presses) produce a wide variety of plastic parts for all types of industries. Mr. Powell credits plastics with lowering manufacturing costs. He cites, "a 9 lb. switch box with walls 1" thick. Inserts, threads and wire openings are all molded in a single cavity mold."

Good mold design, choice of the right material, and sound molding technique require teamwork between the engineering department and the molding plant according to Mr. Powell. "Nowhere is this better evidenced," he says, "than in the 25 lb. 3" thick cores we mold for oil well plugs where case hardening could be a real problem."



Robert B. Battersby, Auburn Button Works, Inc., Auburn, N. Y. Three years before Auburn discontinued button manufacturing for 100% custom molding, engineer Bob Battersby switched from steel design to plastics. That was back in 1942. Today Mr. Battersby is Plant Manager of Auburn's Thermosetting Division, in charge of the design and production of camera parts, adding machine cases, business machine components, along with a wide variety of highly complex, close tolerance pieces for technical uses. "We completely design all molds here" states Mr. Battersby, " and make about 40% of the molds which may range in cost from $500 to $30,000 in our own tool shop." With "service, quality, and price" foremost, Bob has promoted the expansion of high speed plunger molding equipment to improve quality and reduce costs.

Mr. Battersby emphasizes that "firms planning to use plastics should call in the custom molder in the first stages of design to take advantage of the molder's broad experience and assure the best product at the lowest cost."

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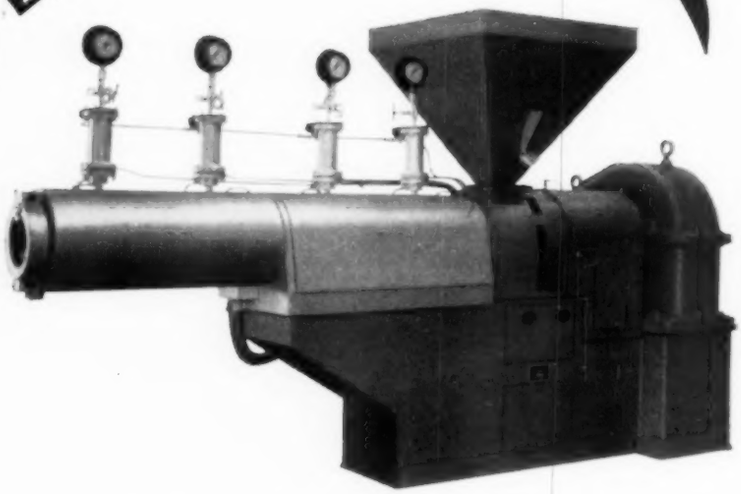

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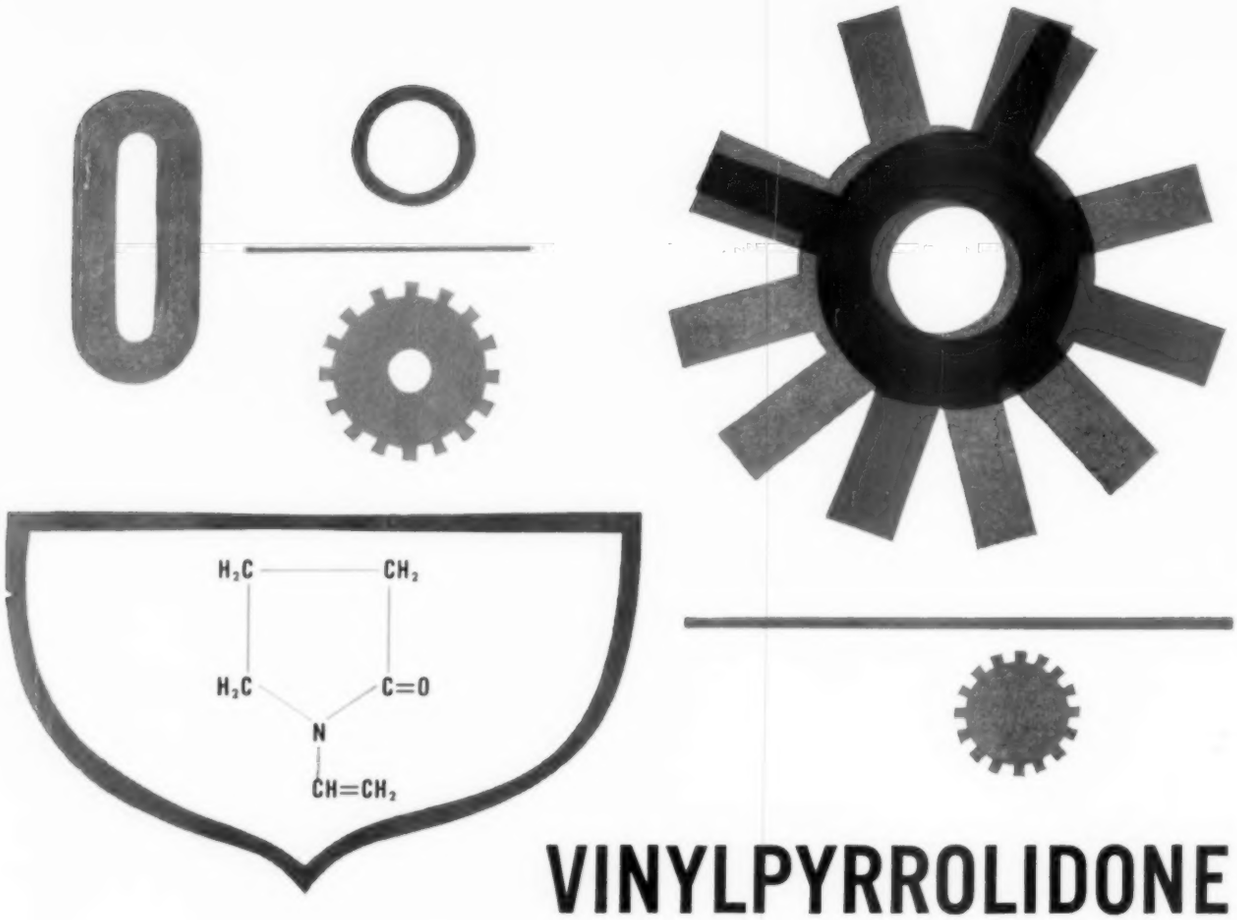

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From Research to Reality

The Effect of Additions of

High Melting FT Waxes To Polyethylene in the Manufacture of Containers

Gerhard Benthin

AMONG THE SYNTHETIC MATERIALS, the high polymer olefins, polyethylene and polyisobutylene, have a special position with regard to their water vapor transmission. The diffusion values for water vapor are smaller than those of the other known synthetics, as per Table I. They are lower by one power than the values of vulcanized rubber mixtures, PVC and polystyrene, and by two powers than those of polyacrylate, cellulose triacetate and other cellulose derivatives. Still lower, however, than the water vapor transmission value of polyethylene and polyisobutylene, and by a full power at that, is the value for paraffin.

The above observations stimulate the idea to conduct experiments to establish whether Paraffin Waxes can be used to obtain a further improvement in the properties of Polyethylene.

Among other things, Polyethylene is used to manufacture packaging materials, such as foils and containers, Polyethylene bottles are suitable for storing neutral, acidic and alkaline aqueous liquids. Also a number of organic liquids, such as alcohol, do not attack the bottle walls even after prolonged exposure. Larger bottles made from polyethylene, however, have the disadvantage that they are difficult to handle as a result of their flexibility. It is possible that the contents gets squeezed out of the open bottle during handling by pressure on the container walls. This effect can be minimized by increasing the thickness of the walls or by mixing into the Polyethylene substances which, under conditions of mutual compatibility, increase its hardness and rigidity. Polyethylene of a molecular weight of approximately 20,000 to 25,000, such as is used generally for the manufacture of bottles and foils, has a melting point of 112-115° C (233-235.5° F); under conditions of continuous exposure its heat resistance is limited to approximately 80° C (176° F).

By the addition of ordinary paraffin, as, for example, fully refined paraffin, melting point 122-132° F, the softening point of the polyethylene would be considerably reduced. To the extent, therefore, that paraffinic admixtures are desirable, the search will be for waxes which equal or approach in their solidification and melting points those of polyethylene.

High Melting Hard Mineral Waxes

Such waxes are obtained through the Fischer-Tropsch synthesis where, depending upon the selection of the catalyst and other operating conditions, minor product differences result. If cobalt is used as a catalyst and working under atmospheric pressure, the solidification point of the highest melting fraction of the synthesis product is in the neighborhood of 90° C (194° F). By using an iron catalyst and operating under ten times atmospheric pressure, mineral waxes (the so-called FT waxes) with a solidification point of 96-100° C (205-212° F) are obtained; their capillary melting point is 108-110° C (226-230° F). These FT waxes deviate very little in their melting point data from those of Polyethylene; they are, therefore, interesting for mixtures with this synthetic.

Also in their chemical constitution both materials show similarities. According to H. Hopff[1], technical Polyethylene consists of chain molecules which carry after each 15 to 20 carbon atoms a methyl group as a side chain. The hard FT mineral waxes are also thought to consist of long chains with methyl side chains although this could not yet be absolutely proven. In any event, there must be a difference in the construction of Polyethylene as compared with the FT mineral waxes: Even if the molecular weight of the latter is further increased into the range of the flexible Polyethylene (to approximately 10,000) it still remains a hard, Paraffin-like material.

Effect on the Rigidity

Due to their similar structure, Polyethylene and synthetic FT Wax 300 are miscible and compatible with each other in any proportion. Polyethylene at room temperature has 60-75% crystalline components. Only at 115° C (235.5° F) the total mass changes to an amorphous struc-

TABLE I

Water vapor transmission D of various synthetics at 25°C; D values in 10^{-8} g h $^{-1}$cm^{-1} Torr^{-1}; according to H. Heering, H. Puell and I. Drewitz, Kunststoffe, Volume 38 (1948), page 49.

Paraffin	0,02
Polyisobutylene	0,14
Polyethylene	0,22
Bitumen	0,80
Rubber Mixtures, Vulcanized	0,80–5,0
Gutta Percha	1,3
Polyvinylchloride	2–10
Polystyrene	3,3
Benzyl Cellulose	16
Polyacrylate	31
Cellulose Hydrate	77–200
Cellulose Triacetate	100

[1] *H. Hopff, Chemische Industrie, #3 (1951), Page 632. Translated from the Journal "KUNSTSTOFFE", March, 1956.*

ture. The FT Wax is crystalline, though microcrystalline. It can be expected that its crystallities pack tightly with the crystalline components of the Polyethylene; a separation of the mixture upon aging is, therefore, not to be feared and in practice has not been noted. Through the addition of highly amorphous polyisobutylene a further improvement of the nature of the mixture can be effected.

The combined crystalline structure of the Polyethylene and the synthetic FT mineral wax has a very favorable effect on the rigidity of containers made from such mixtures. Bottles manufactured from such combinations have a harder, more agreeable "hand" than those manufactured from pure Polyethylene. They are more solid and less easily compressible, depending on the quantity of FT Wax used in the blend. The opaque appearance of the Polyethylene is greatly increased by the addition of the FT Wax.

Vapor Transmission Barrier

Of decisive importance, however, for the practical suitability of such bottles should be their water vapor and alcohol vapor tightness, in which respect an improvement can be expected for the reasons cited above. To explore this question, we prepared bottles of approximately 47 ccm. capacity from the following compositions:

(a) Pure Polyethylene (molecular weight 20,000)

(b) 90 parts, by weight, Polyethylene
10 parts, by weight, Synthetic FT Wax-300[2] solidification point 98°C)

(c) 85 parts, by weight, Polyethylene
15 parts, by weight, Synthetic FT Wax-300[2]

(d) 80 parts, by weight, Polyethylene
20 parts, by weight, Synthetic FT Wax-300[2]

These bottles were filled with water to the extent of approximately 2/5 of their capacity, sealed and stored at a temperature of 26°C (79°F). Every day at the same time the weight was determined. The difference in the weight loss of the individual bottles was especially great in the first two days. If the weight loss from the bottle made of pure Polyethylene (a) is taken at 100, the losses from the other bottles were as follows:

(b) 66 (c) 60 (d) 30.

[2] *Distributed in the United States and Canada by Dura Commodities Corporation, New York, N.Y.*

After six weeks' storage, the weight of the bottle made from pure Polyethylene (a) had been reduced by loss of water by 20.8 mg. In the same space of time, the bottles made with additions of synthetic mineral wax FT-300 showed the following weight losses:

(b) 16.8 mg = 77% of (a)
(c) 14.8 mg. = 71% of (a)
(d) 13.9 mg. = 66% of (a)

In a similar manner we made tests with 95% alcohol denatured with benzol. Here, too, the same phenomenon during the initial period was observed as in the case of the test with water. While the loss from the Polyethylene bottle was 4 mg. alcohol, the weight decrease of the bottles made with the FT Wax blends was as follows:

(b) (90/10) 45% (c) (85/15) 38% (d) (80/20) 35%.

In the days following, up to an indefinite storage period, the weight losses relative to bottle (a) = 100 were:

(b) 67 (c) 59.7 (d) 58.

Thus, relative to the transmission for alcohol vapor, the admixture of FT Wax-300 gives even more noticeable effects than in the case of water vapor. But it is not possible to make any definite statements as to the most desirable portion of FT Wax to use.

Gas Transmission Barrier

The gas diffusion through Polyethylene is reduced by the admixture of high melting FT Wax in a similar manner as the water vapor and alcohol vapor diffusion, as was shown by the following experiments:

The Polyethylene, respectively Polyethylene/FT Wax, bottles of 47 ccm. capacity were provided with a sealed-in glass tube of 7 mm. interior diameter and were filled for the first experiment with hydrogen and for the second experiment with CO_2. The glass tubes were sealed off from the outside air by flat immersion into water and were stored under conditions of constant temperature. Already within a few hours it could be noticed that the water rose in the tubes. The more FT Wax that was contained in the bottle composition the less gas was diffused through the walls of the bottle and the less was the rise, as can be readily seen from Table II.

TABLE II

Gas Diffusion of Polyethylene relative to Paraffin Content expressed in comparative rise of water in immersed glass tubes.

	Composition of Bottle	Relative Degree of Rise Hydrogen	CO_2
(a)	Pure Polyethylene	100	100
(b)	90 parts Polyethylene 10 parts FT Wax-300	78	85
(c)	85 parts Polyethylene 15 parts FT Wax-300	70	72
(d)	80 parts Polyethylene 20 parts FT Wax-300	55	64

Odor Barrier

In the use of Polyethylene bottles for perfumes and cosmetics, it is disadvantageous that Polyethylene has a low odor barrier. In order to examine the influence of admixtures of FT Wax on the odor barrier, two cloves were put into each of the bottles made from Polyethylene and from Polyethylene/FT Wax compositions, as described above. The bottles were sealed and stored at a distance from each other of approximately one yard in a room without air movement. Several outside persons were requested to grade the bottles according to their odor intensity, at different time intervals. According to almost concurrent judgment, a reduction of the odor intensity was observed parallel with increasing proportions of FT Wax in the bottle composition. But it cannot be said that the odor barrier was complete.

Conclusions:

The reported test data seem to indicate that the addition of high melting synthetic FT Wax-300 to Polyethylene offers a series of measurable advantages. This data should be of special interest for the manufacture of containers and packaging foils from high pressure Polyethylene. Tests are being continued.

"FT Wax" is a registered trade mark of Dura Commodities Corporation.

On Aging of Urethane Foams

Joseph Winkler
American Cello Corp.

THE manufacture of resilient urethane foams belongs presently to the main large scale commercial uses for polyisocyanates. Such foams are made predominantly by using N-toluene diisocyanate, containing from 65 to 80% of 2,4 toluene diisocyanate, the balance being the 2,6 toluene diisocyanate isomer. The second basic component for the manufacture of resilient foams is a hydroxyl-terminated polyester containing at least two hydroxyl groups per molecule. Such a typical polyester can be made from one mole of adipic acid, one mole of diethylene glycol, and 0.1-0.01 mole of trimethylol propane. The average properties of this type of polyester are: hydroxyl number—42 to 63; acid number 1.5 maximum; water content .1% maximum: density 1.19 at 77°F; flashpoint (open cup)—525°F (approx.); viscosity at 72°F, 7,000 to 12,000 cps. (approx.); color—Gardener #1 maximum.

The toluene diisocyanate is reacted with a polyester and water in the presence of an emulsifier (s), an accelerator (catalyst) whereby the schematic reaction is as follows:

2 OCN-RNCO + HO-polyester – OH + H_2O →
– NH-RNH-COO – polyester-00C NHRNH –

where R is a toluyl group.

The water reacts separately at the same time with the -NCO group converting it to a reactive -NH_2 group and frees CO_2 gas, which serves as a blowing agent.

During the initial years of foam making, which was first concentrated in Germany, so many production problems were involved in making resilient foams of a marketable quality, that little attention was given to causes of progressive loss of resiliency, reduction of tensile strengths and increase in compression set which takes place during natural aging. Of course it was soon recognized that a proper ratio of the diisocyanate to the polyester was an absolute requisite in order to make a slow aging resilient foam. It was therefore established, and now it is a common practice, that any resilient foam must be made with an isocyanate/polyester and water index of more than 100, preferably 105 to 110, in order to have a slow-aging, resilient foam. But nothing which may be significant was apparently done to clarify the role of the catalyst in foaming-aging as long as the catalyst enabled the manufacture of faultless blocks of a resilient foam without collapse, blow-outs, voids, shrinkage, holes and other imperfections.

Only recently by independent research, by the Mobay Chemical Co. and duPont de Nemours & Co., Inc., information became available which points to the fact that the physical-chemical properties of the activator play a significant role in the aging velocity of resilient foams. (See duPont's HR-15, 5-15-56, "Analytical Studies on the Aging of Isocyanate Based Foams;" also corresponding bulletins of Mobay Chemical Company).

It was recognized that when the activator used in the foaming process remains in the foam, it acts in reverse, which means that it activates the depolymerization of the foam under the influence of humidity and elevated temperatures. For that reason, it was recommended to use either high-volatile activators, or to heat the foam in a post-curing process in order to facilitate the evaporation of the activator. But post heating of the foam is an additional operation which requires further equipment and increases the cost of manufacture. On the other hand high-volatile activators are at the same time too active and difficult to control.

The purpose of this research has not been to find out what chemical changes occur in the foam during natural or accelerated aging. This has already been done by duPont chemists and results were published in the brochure mentioned above. This study therefore was undertaken to find out whether there can be found an activator which may not require removal from the foam by a post-heating process, but which could be tied into the foam structure, and thus inactivated. Also the purpose of this study was to find out differences in foam properties, depending on the used activator.

In order to make such a comparison under reasonable conditions, the following conditions of materials and procedure have been constantly maintained:

1. The polyester used was Multron R-18 of Mobay Chemical Co.
2. The M-toluene diisocyanate used was Mondur RD of Mobay Chemical Co., which is toluene diisocynate 65/35.
3. The emulsifier used was Emulphor EL-719 from Antara Chemical Co.
4. The foam was made in a batch mixer in a two-component, one-shot operation, while the water-emulsifier-activator solution was pre-mixed with the polyester.
5. Mixing temperature — 25°C.
6. Mixing time — five seconds. During mixing a slight vacuum was maintained avoiding air-occlusion into the batter.
7. Mixing speed — 3,000 rpm.
8. Foaming time (including 5-second mixing time)— 95-105 seconds.
9. Emulsifier amount — 2.5wp/100 wp. polyester.
10. Water amount — 3.5wp./100wp. polyester.
11. Mondur TD — 48wp./100wp. polyester.
12. Activator amount varied from 0.5 to 3.0wp./100wp. of polyester. (The exact amount for each activator was established in previous screening tests — **the proper amount being the one which was** sufficient to give a foaming time always equal to 95-105 sec.

As can be seen from this itemization, the only variable was the type and amount of the activator. All other conditions have been the same for all foaming experiments. It should be mentioned here that 95-105 seconds foaming

This paper was presented at the Isocyanate Symposium sponsored by the Upper Midwest Section of SPE.

time is not an arbitrary figure. This figure is a result of actual practice during the last three years of commercial foaming, in which it was established that the best foaming conditions are those during which the foaming time is not shorter or longer than 95 to 105 seconds for a 2-lb./cu. ft. resilient foam. This foaming time is measured from the moment when all the components are mixed together to the moment when the foam stops rising; which is marked often by a release of an excess gas bubble through a small blister on the surface of the foam skin. Shorter foaming time than 95 to 105 seconds

Table I

FOAM SAMPLE	AGEING PERIOD DAYS	DENSITY Lbs./cu. ft.	TENSILE Strength psi.	TENSILE Elongation 250°C %	TEAR RESIST. Lbs./in.	COMPR. SET 70°C, 22-hrs. %	COMPR.-DEFL. Lbs./sq. in. 25%	COMPR.-DEFL. Lbs./sq. in. 65%	REMARKS (See Below)
#1	0	2.2	20	208	2	6.0	3.6	1.1	2.2
	7	-	19	210	3	5.0	3.0	1.2	2.3
	14	-	17	220	3	5.0	4.0	1.2	2.3
#2	0	2.1	15	180	1	4.0	4.8	1.0	1.9
	7	-	14	160	3	4.0	3.8	1.1	1.9
	14	-	11	168	5	4.0	7.0	1.0	2.0
#3	0	2.15	23	180	2	5.0	7.5	0.6	1.8
	7	-	20	175	3	5.5	9.0	1.0	2.0
	14	-	16	165	4	4.5	12.0	0.9	2.1
#4	0	2.10	22	170	4	5.5	8.0	0.7	1.9
	7	-	20	180	5	6.0	10.0	0.8	1.7
	14	-	18	190	6	6.0	13.0	0.9	1.7
#5	0	2.25	14	260	9	3.5	9.0	0.6	1.0
	7	-	10	280	15	5.0	15.0	0.6	0.9
	14	-	8	310	21	2.0	25.0	0.9	0.1

REMARKS: - #1 Sample - Foam blocky, fine-elastic with small dispersed.
#2 " - Foam coarse, with small dispersed.
#3 " - Foam medium soft, with larger inside cracks.
#4 " - Foam soft, with bottom splits
#5 " - Foam very soft, bottom splits.

for a foam of a density from 1.8 to 2.2 lbs. cu. ft. leads often to surface blowouts, while longer foaming time is inducive to the creation of interior voids, bottom splits, and also often produces foam collapse. This quantitive and qualitative arrangement in the foam making is very similar to the one which is actually being used in the commercial manufacture of resilient foams. Therefore, the obtained results are with small corrections in formulations, reproducible on a commercial foaming machine. This means that the results in this study reflect to a large degree results which may be expected in foams made on a commercial machine.

All foams produced under these conditions have had a very similar density in the limits of 1.9 to 2.3 lbs./cu. ft. and an average cell size from 1/64" to 1/32". However, due to different activators used in this study, other properties of the foam varied considerably, especially the texture of the foam varied from very soft to firm-elastic. Other physical differences in properties of these foams are shown in Tables I and II in the lines characterized by zero — aging time.

For making resilient urethane foams, numerous activators (catalysts) were proposed in previous publications and patents. Only those activators were used which belong to one class — the class of tertiary amines, because only activators from this class are being generally used in resilient foam manufacturing.

From the tertiary amine class, the following five groups of compounds have been investigated:

1. Pure tertiary amines	2 compounds
2. N-alkyl-morpholines	3 compounds
3. Tertiary aminoalcohols	3 compounds
4. Tertiary aminophenols	2 compounds
5. Tertiary esteramines	2 compounds

Eleven of those twelve tested tertiary amines are known commercial products, only the last one (#12) is a new compound used for the first time for that purpose.
From the first group:

1. Triethylamine — B.P.-90 C/760mm. Hg — made by Carbon & Carbide Chemical Corp.
2. N,N'dimethylcyclohexylamine — B.P.-139°C/760 mm. Hg — from an European manufacturer.

From the second group:

3. N-methylmorpholine — B.P.-115°C/760mm. Hg.— made by Carbon & Carbide Chemical Co.
4. N-ethyl morpholine — B.P.-138°C/760mm. Hg. — made by Carbon & Carbide Chemical Co.
5. N-coco morpholine — B.P.-135 to 165°C/.5mm Hg. — made by Armour Chemical Co.

From the third group:

6. Dimethylaminoethanol B.P.-135°C/760mm. Hg. — made by Sharples Chemical Co.
7. Diethylaminoethanol B.P.-162°C/760mm. Hg — made by Sharples Chemical Co.
8. Dibutylaminoethanol B.P.-222 to 234°C/760mm Hg — made by Sharples Chemical Co.

From the fourth group:

9. Dimethyl aminomethylphenol — B.P.-80 to 130°C/ 2mm Hg — made by Rohm & Haas Co.
10. 2,4,6 tri-(dimethylaminomethyl) phenol B.P.—145-155°C/mm Hg — made by Rohm & Haas Co.

From the fifth group selected:

11. Bis (diethylaminoethyl) adipate — B.P. -177 to 180°C/1mm Hg—from a European manufacturer.
12. Tetrakis (2-diethylaminoethyl) ethylene dinitrilotetra acetate B.P.-189 to 195°C/1mm Hg — a new compound: synthesis confirmed through the courtesy of Sharples Chemical Co.

The resulting resilient foams are identified by the same numbers as the activators used and the results of tests made on those foams before and after aging for 7 and 14 days are presented in Tables I and II.

In analyzing the results presented in Table I and II we have to bear in mind that the accuracy of the presently

Table II

FOAM SAMPLE	AGEING PERIOD DAYS	DENSITY Lbs./cu. ft.	TENSILE Strength psi	TENSILE Elongation 250°C %	TEAR RESIST. Lbs./in.	COMPR. SET 70°C 22-hrs. %	COMPR.-DEFL. Lbs./sq. in. 25%	COMPR.-DEFL. Lbs./sq. in. 65%	REMARKS (See Below)
#6	0	2.2	17	215	7	5.0	6.0	0.75	1.40
	7	-	16	220	9	6.0	7.0	0.90	1.50
	14	-	14.5	208	12	6.5	10.0	0.78	1.55
#7	0	2.1	20	250	6	6.5	6.0	0.70	1.35
	7	-	20	260	7	6.0	5.5	0.80	1.25
	14	-	17	208	9	6.5	7.5	0.90	1.35
#8	0	2.0	21	260	10	4.0	4.0	0.60	1.10
	7	-	23	270	12	4.0	15.0	0.50	0.90
	14		10	210	12	3.0	13.0	0.35	0.60
#9	0	2.3	16	250	9	5.0	9.0	0.55	1.0
	7	-	17	290	18	3.5	16.0	0.50	0.8
	14		16	230	21	2.0	30.0	0.30	0.6
#10	0	2.1	17	258	10	5.5	8.5	0.65	1.1
	7		15	280	13	3.0	12.0	0.50	0.9
	14		17	310	19	2.5	18.0	0.55	0.8
#11	0	2.0	21	175	9	6.5	5.5	1.15	2.3
	7		20	190	9	6.0	5.5	1.10	2.1
	14		17	155	9	5.0	5.0	0.90	1.9
#12	0	1.9	28	245	8	7.0	5.0	1.10	2.3
	7		30	260	9	7.0	6.0	1.08	2.1
	14		27	250	10	6.5	6.5	0.98	2.1

REMARKS: - Sample #6 - Foam medium soft, some small inner splits.
" #7 - Foam medium soft, some small inner splits
" #8 - Foam medium soft, some inner intercellular breaks and voids.
" #9 - Foam soft, intercellular cell structure.
#10- Foam medium soft, almost no defects.
#11- Foam firm, uniform cell structure - no defects.
#12- Foam firm uniform cell structure.

available testing method for urethane foams is not very good and testing results obtained with the same samples in different laboratories, but also by the same laboratory showed deviations — ±25% and sometimes more. When taking this low testing accuracy into account, the only reasonable deductions which can be made from the testing data are the ones which show considerable differences between the twelve tested foams. Such considerable differences we see only in tensile strengths, compression set, elongation set, also in compression-deflection for fresh foams and after 7 and 14 days of aging. There are, of course, considerable differences in initial tensile strengths,

elongation and compression set and compression-deflection between different foams. Those differences are reflected in texture of the foams which also varied from soft-elastic to firm-elastic.

In looking over Tables I and II from this point of view, and comparing those results with the boiling or distillation temperatures of the individual activators, we can see a fairly good relationship between the degree of aging and the volatility of the activator. It seems that foams when tested soon after the skin surface has been cut off, and which have been foamed with a low-boiling activator, age more slowly than foams made with a higher boiling activator. This is evidenced by comparing Foams 1 and 2 in Group I, and foams 3, 4 and 5 in Group II. Less pronounced are the results in Group III for foams 6, 7 and 8. In this group, however, we have all the activators containing one active hydrogen in its OH group, which presumably during the foaming, allows a partial tie-in of the activator into the foam, and thus eliminates most of its later depolymerization activity.

Aging of the Foam

Very pronounced, however, is the aging of the foam made with activators from Group IV — 9 and 10. Those two activators have a relatively high boiling temperature and consequently they remain much longer in the foam because of slowness of evaporation. While they do contain an active hydrogen in their phenolic OH group, it seems that this active hydrogen was not tied-in sufficiently into the foam macro-molecule.

In foams of Group V, 11 and 12 — we see two entirely different results. Those two activators both belong to the group of amino esters. Both are high boiling liquids and should, therefore, give foams susceptible to humidity aging. On the other hand, amino esters are known to be the most reliable foaming activators because of the uniformity with which they activate the complicated primary and secondary reactions between the polyisocyanates, polyesters and water. This uniformity is highly important; otherwise we obtain foams in which the CO_2 production would be faster or slower than the build-up of the urethane polymer which will result in collapses or blow-outs of the foam. As a matter of fact, activator 11 is still presently the most widely used activator in commercial manufacture. But it was recently recognized that this activator is deficient because it makes foams susceptible to hydrolysis-aging in a higher degree than, for example, foams made with activators 4 and 6 respectively. Those two low-boiling activators, although giving aging resistant foams, still present problems in foam manufacture. Their activity is pretty difficult to control, and as a result, very often foams have surface blow-outs, holes and other imperfections. Also, the working personnel often object to their obnoxious odor.

Finding Reliable Activator

One of the purposes of this study was, as it was mentioned in the beginning, to find an activator which would be reliable in foaming like activator 11 and which would not afterwards cause premature aging. The testing of amino esters were also considered, but the requirement was that it should completely tie-in during the foaming process into the foamed macro-molecule.

It is known that alkaline salts of ethylenediamine tetra acetic acid have valuable chelating properties. Based on this property, it was decided to make a tetra ester from this acid and diethylamino ethanol. To the best of my knowledge no such ester was ever made. Such an ester of high purity was made, which was later reproduced through the courtesy of the Sharples Chemical Company.

Here are the properties of Activator 12:

Appearance—clear, medium viscous yellow oily liquid
Odor—faint, not unpleasant
Water Solubility—less than .1%
Specific Gravity at 20°C—1.036
Refractive index at 25°C—1.4274
N-content (Kjeldahl) 11.88%
Purity—97½%

Activator 12, being a high molecular esteramine with the lowest relative volatility, when used in the amount of 3wp./100wp of polyester, gave excellent resilient, medium-firm foams with superior properties as it is seen from Table II, #12. We see also from this table that its aging properties have been superior to any other foam from #1 to #11. As a matter of fact, a 14-day aging period did not affect its properties to any appreciable degree. This proves the initial assumption that such a tetra ester of diethylaminoethanol and ethylene diamine tetra acetic acid should have properties allowing for its tie-in into the foam during the foaming process. What actually happens is a matter for further investigation. This specific tertiary ester amine may contain at least two, and perhaps up to four active hydrogens in each molecule which react with the polyisocyanates and consequently the activator becomes inactivated.

A simple experiment seems to prove this assumption. When mixing under a dry nitrogen blanket equal weight parts of activator 12 and toluene diisocyanate, (at room temperature) the resulting clear low-viscosity solution, by itself, without further heating during an hour heats up to 50°C and solidifies to an amber-colored resin. No such resinification takes place when mixing equal parts of activator 11 and toluene diisocyanate.

Conclusions:

Degradation of resilient polyester-urethane foams during service is attributed to the combined action of temperature and humidity—humidity being the more important factor. This degradation of resilient polyester urethane foams is accelerated by the presence of residual alkaline activators used in the foaming process.

This study contains the results of foaming of typical resilient polyester foams with twelve different activators, and their properties before and after aging for 7 and 14 days are tabulated and compared. Those twelve catalysts belong to five classes:

1. Pure tertiary amines
2. N-alkylmorpholines
3. Tertiary aminoalcohols
4. Tertiary aminophenols
5. Tertiary ester amines

There has been found a direct relationship between the volatility of the catalyst and aging susceptibility of the foam, in which high-volatile catalysts produce low-aging foams and vice versa. Foams with good hydrolysis-aging properties result when using high-volatile activators like triethylamine, N-methylmorpholine or dimethylaminoethanol, but because they are at the same time of a high reactivity they are more sensitive to fluctuations of working conditions. As tertiary ester-amines are more suitable for a reliable commercial foaming of uniform, low-density foams, attempts have been made to find a proper tertiary ester amine which after catalyzing the foaming reaction, would be inactivated by tying it into the foam itself. Such an activator, which is a tetra ester of diethylaminoethanol and ethylenediamine tetra acetic acid, has been for the first time synthesized and tested in this respect. The resulting resilient foam has superior properties which do not change even after 14 days of humidity-aging.

Control of Chemical and Physical Factors in the Application of Casting Resins

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THE WIDE VARIETY OF commercially available casting resins is based on a few basic types of polymers. It is desirable therefore to know a few characteristics of these polymers which influence casting. These characteristics can be conveniently discussed in terms of pot life or working life and volume changes during cure.

1. **Pot life**—The pot life or working life of a casting resin is defined as the time interval between the initial mixing of all components of the casting resin and the polymerization of the resin to a viscosity beyond which it is impractical to apply. The estimation of pot life of a given resin composition is made by two methods: (1) direct measurement on a resin under a given set of experimental circumstances and (2) determination of the curing kinetics for a given resin composition as applicable to the given set of experimental circumstances; i.e., allowance must be made for the nonisothermal character of the cure, the presence of air on the cure, the effects of surface moisture on the cure, and the like.

The first method is used most frequently and is satisfactory, provided a limited set of physical conditions are encountered and provided it is not necessary to make frequent changes in chemical composition of the casting resin. The second method requires a considerable amount of data, often not easily obtained; however, once such data is available, complete quantitative control of the casting process is possible under a wide variety of circumstances and employment of wide variations in chemical composition.

Once the kinetics of cure of a given resin composition is known, it is possible to calculate the extent of cure versus time provided the cure is accomplished under adiabatic conditions. A knowledge of viscosity relationships for the resin, combined with the curing curve, would allow quantitative estimation of the pot life. Since potting resins are poor heat conductors, essentially adiabatic curing is encountered under conditions such as large dimensions of casting specimen and fast rate of cure.

The basic curing mechanisms for casting resins are comprised of (1) free radical chain reactions, (2) nucleophilic displacement reactions, and (3) carbonium ion reactions. The free-radical type of reaction occurs in the cure of vinyl polymers and is usually far more sensitive to experimental conditions than the other reactions mentioned. A thorough coverage of the principles of vinyl polymerizations is available in the literature (Cf. Ref. 1). The complex effect of oxygen on the cure of vinyl polymers is an important consideration when these materials are used as casting resins.

There is another effect which occurs in the bulk polymerization of vinyl polymers, and it is even more significant in its influence on casting. It has been observed that styrene and other vinyls show an acceleration in cure as the reaction proceeds even under isothermal conditions. This acceleration in cure combined with that arising from the rise in temperature associated with the exothermic reaction leads to an extremely sudden cure of these materials after a certain stage of polymerization has been reached. The acceleration of rate of vinyl polymerizations has been explained by reference to the following rate equation:

$$-dn/dt = k_p (k_i/k_t)^{1/2} C^{1/2} n \qquad (1)$$

where

n = monomer concentration (moles/cc)
C = catalyst concentration (moles/cc)
k_i, k_p, k_t = rate constants for initiation, propagation and termination

It is believed that k_t decreases as the viscosity of the medium increases since the mobility of the free radical chains which combine in the termination process would be reduced (Cf. Ref. 1). The net result is an increase in the rate of disappearance of monomer, since k_t enters into the denominator of the rate expression.

The autoacceleration effect and the sensitivity of vinyl polymerizations to external factors render difficult the exact calculation of curing curves. Polymerizations which proceed by the more straightforward nucleophilic substitution mechanism such as polyurethane formation and base-catalyzed epoxide reactions yield kinetics easily amenable

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to the calculation of extent of cure versus time. To illustrate the procedure involved in the calculation, it will be assumed that the curing reaction is of the a th order. The corresponding rate expression is

$$-dn/dt = kn^a \qquad (2)$$

Since the reaction is not conducted under isothermal conditions, the rate constant will have the usual Arrhenius-type temperature dependence

$$k = B \exp\left[-A/R\,(\Delta T + T_0)\right] \qquad (3)$$

where

A = activation energy (cal/mole)
R = gas constant (cal/mole-deg K)
T_0 = initial temperature of monomeric material
ΔT = temperature rise resulting from heat of reaction

If the reaction is conducted under adiabatic conditions, ΔT can be expressed as

$$\Delta T = \left[(n_0 - n)/n_0\right] Q/\bar{c} = \alpha Q/\bar{c} \qquad (4)$$

where

$\alpha = (n_0 - n)/n_0$
Q = heat evolved per gram on complete polymerization
$\bar{c}$ = average specific heat of casting resin

When equations (2), (3), and (4) are combined and integrated, the following relation for the curing time results:

$$t = (1/Bn_0^{a-1}) \int_0^{1-\epsilon} (1-\alpha)^{-a} \exp\left[A/R\,(Q\alpha/\bar{c} + T_0)\right] d\alpha \qquad (5)$$

In order to evaluate the "time integral" of equation (5), it is convenient to resort to the following approximation which holds fairly well as long as $\Delta T << T_0$:

$$1/(T_0 + \Delta T) \cong (1/T_0)(1 - \Delta T/T_0) \qquad (6)$$

Combining equations (5) and (6) gives the following approximate expression for the curing time:

$$t \cong \left[\exp(A/RT_0)/Bn_0^{a-1}\right] \int_0^{1-\epsilon} (1-\alpha)^{-a} \exp(-AQ\alpha/RT_0^2\bar{c})\, d\alpha \qquad (7)$$

In the early stages of a vinyl polymerization exhibiting the autoacceleration effect, the diminution in rate resulting from material depletion is closely counterbalanced by the increased rate due to the decrease in k_t. The resulting curing curve approximates that for a zero-order reaction, and it is possible to estimate this curve by the following equation derived from equation (7):

$$t \cong (n_0 \bar{c} RT_0^2/B_0 AQ) \exp(A/RT_0)\left[1 - \exp(-AQ/RT_0^2\bar{c})\right] \qquad (8)$$

The above calculation of a curing curve was illustrated by the use of a relatively simple reaction. The actual kinetics of a polymerization is frequently more involved. For example, epoxide polymerizations are under most conditions third order reactions and polyurethane polymerizations often involved fractional orders in the rate expressions. These complications do not prevent the straightforward applications of the above calculation procedure; however, the time integral is seldom directly integrable in any event. It is desirable in plotting the results of calculations to use the familiar procedure of reduced variables in most cases.

Once having developed the equations for calculating curing curves, a simple examination of the variables involved suffices to indicate how to control the rate of cure. As long as the reaction is nonisothermal, the heat of reaction is an important variable in accelerating the cure. There are other reasons, too, why the heat of reaction should be given close attention. The temperature rise corresponding to a given heat of reaction is shown in equation (4). Quite obviously, if this temperature increment, added to the initial temperature of the casting resin ingredients, exceeds the decomposition point of the reactants or products, difficulty will be encountered. Often a polymerization conducted at elevated temperatures does not yield a polymer of high molecular weight. This is particularly true of vinyl polymerizations. Another difficulty most commonly encountered is that the temperature rise results in a temperature which exceeds the boiling point of the monomeric material in the casting resin. The resulting bubble formation and thickening of the resin produces a poor casting.

Counteracting Heat Reaction

To counteract the effect of the heat of reaction, it is necessary to resort to one or more of the following: (1) add inert fillers or plasticizers, (2) start with partially polymerized materials, or (3) remove the heat of reaction while conducting the reaction in stages. The addition of inert fillers or plasticizers merely lowers the effective heat of reaction in proportion to the amount of heat added. The use of a filler means that a composite system must be considered, and it is pertinent to ask whether or not relatively small amounts of filler would be effective since there might be regions of resin very much larger than the filler particles, and local heating would occur. The device of starting with partially polymerized materials is quite useful. However, in the case of vinyl polymerizations there are limitations. The limitation results from the fact that vinyl polymerization most often proceeds by the formation of polymer of high molecular weight only; i.e., at various stages in the polymerization there is essentially high molecular weight polymer and monomer. Therefore, even at low conversions the viscosity of the solution is high and often unworkable.

The removal of heat by conducting the reaction in stages is frequently done. Since casting resins are poor conductors, the success encountered in removing heat will depend largely upon the sample size in combination with a practical time for cure. A long cylindrical specimen, 5 inches in diameter, loses relatively little heat from the center of the charge. A more detailed quantitative discussion of heat transfer in cylindrical charges will be given in section III.

2. Shrinkage—Another problem of importance in obtaining proper casting is that of shrinkage. There are essentially two kinds of shrinkage which enter into consideration. One involves the shrinkage accompanying the conversion of monomer to polymer, and the other occurs as a result of the difference in thermal coefficients of expansion of the casting resin and the embedded component.

The reduction of shrinkage during polymerization can

be handled in much the same way as the reduction of heat of reaction, i.e., the addition of inert diluents and casting in separate stages. In this case, however, material addition rather than temperature conditioning must be done in stages.

It is often possible to estimate whether or not a given system is likely to present a problem in shrinkage by merely taking advantage of the additivity of atomic volumes. The shrinkage expected on the polymerization of methyl methacrylate is 21.2% as compared with 20.6% obtained experimentally. The epoxides are unusual in this respect since the same bonds exist before and after polymerization. The only difference in reactants and products with respect to bonds is the presence of the ring structure which would have only a small effect on net atomic volume. This qualitative conclusion is amply verified by the low experimentally observed shrinkage of the epoxides.

The shrinkage problem which arises from differences in thermal coefficients of expansion is best treated by employing a casting resin with sufficient elongation at all operating temperatures and strain rates to withstand the strain imposed by the volume change of the metal component. A specific example of this type of problem is as follows: Suppose a casting resin is cured in a metal cylinder, and it is required that a small perforation in the casting resin be located along the center axis with respect to the cylinder. Since the casting resin is adhered to the side of the cylinder, any expansion or contraction of the cylinder wall will cause a simultaneous strain at the perforation of $(b/a)^2 S_w$, where S_w = strain at wall, b = diameter of cylinder, and a = diameter of perforation in casting resin. This magnification in strain at the perforation of the casting resin might easily cause failure of the material.

III. Heat-Transfer Problems

The release of heat in a poorly conducting medium and the effect on the resultant temperature rise or further release of heat produce a difficult problem in the practical application of casting resins. The quantitative description of the transfer of heat under such circumstances is a formidable mathematical problem, and attempts to reduce the related equations to simple analytic expressions has not met with success. In order to illustrate the nature of the complexities which arise and to provide quantitative calculations upon which many qualitative features of the process become evident, a number of calculations will be presented. A more detailed account of these calculations is described elsewhere. Seeger (5) has discussed some of the work which has been done on the solution of related problems in one-dimensional rectangular and spherical coordinates. Most attempts at solutions of practical problems have involved the use of linearized forms of such equations (6) Comparison of accurate solutions of the nonlinear equations as described herein with analytic solutions of the corresponding linear equation has shown that linear approximations are usually not adequate.

1. **Heat Release in an Infinite Cylindrical Medium**— It will be assumed that within the boundary of the cylinder which has an infinitely long axis, heat transfer occurs solely by conduction. This assumption is based upon the high viscosity and low mobility of many casting resin compositions.

The general partial differential equation relating to heat conduction in an infinite cylinder containing a medium which generates heat is as follows:

$$\partial T/\partial t = \kappa \left[(\partial^2 T/\partial r^2) + (1/r)(\partial T/\partial r)\right] + \Sigma_i (\dot{Q}_i/\bar{c}) \qquad (9)$$

The term Q_i/c represents the contribution of various sources of heat generation to the rate of temperature rise at each point throughout the medium. When heat is generated by a chemical reaction, it is usually appropriate to represent the temperature dependence by the Arrhenius expression $k = B \exp(-A/RT)$. Introduction of such exponential terms in equation (9) gives rise to nonlinear partial differential equations which cannot be treated by known analytical methods.

2. **Electronic-Differential-Analyzer Solutions** — It was decided that systematic numerical solutions of equation (9) for heat-release terms corresponding to zero-order and first-order chemical reactions would be useful. The two partial differential equations corresponding to these two cases, respectively, were then expressed in dimensionless variable form as follows:

$$\partial y/\partial \tau = \left[(\partial^2 y/\partial \rho^2) + (1/\rho)(\partial y/\partial \rho)\right] + c_0 \exp(-1/y) \qquad (10)$$

$$\partial y/\partial \tau = \left[(\partial^2 y/\partial \rho^2) + (1/\rho)(\partial y/\partial \rho)\right] + c_1 \exp(-1/y) \exp\left[(-1/N)\int_0^\tau \exp(-1/y)\, d\tau\right] \qquad (11)$$

where $y = R(T + 273)/A$; $\tau = K t/r_o^2$; $\rho = r/r_o$; $y(\rho,0) = y_o$; $y(1,\tau) = y_s$; $c_o = QB_o r_o^2 R/KA\, cn_o$; $c_1 = QB_1 r_o^2 R/K\, Ac$; $N = K/r_o^2 B$; $B = B_o$ or B_1; R = gas constant (cal/deg mole); T = temperature (°C); A = activation energy (kcal/mole); K = thermal diffusivity (cm^2/sec); r_o = radius of cylinder; Q = heat liberated by chemical reaction (cal/g); B_o, B_1 = pre-exponential factors for zero- and first-order reactions, respectively; $\bar{c}$ = average heat capacity of medium (cal/g/deg); and n_o = initial concentration of reactant (mole/cc).

The choice of initial and boundary conditions for solutions of equations (10) and (11) was made solely upon practical considerations. In each case it was assumed that $y(\rho,0) = y_o$. The constant y_o was kept in a narrow range around room temperature. The boundary condition most frequently applied in problems to which these differential equations apply can be expressed in the following manner:

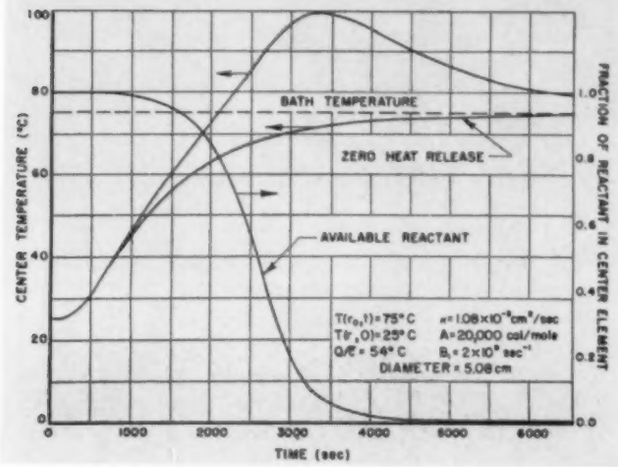
$$\partial y/\partial \rho + h(y - y_b) = 0 \qquad (12)$$

As $h \to \infty$, the boundary condition approached is that of a prescribed surface temperature. The most general solution of the present problem would require use of the boundary conditions in equation (12) when h has a range of values. By assuming a constant temperature at the surface ($h \to \infty$), however, the number of solutions required for coverage of the variables of the problem is reduced considerably.

Equations (10) and (11) were solved with the differential analyzer* by using simultaneous equations describing the heat balance in n concentric regions. For the case of first-order heat release, the difference-differential equations corresponding to these elements were as follows:
Central core

$$dy_0/d\tau = 4(y_1 - y_0)/(\Delta\rho)^2 + c_1 \exp(-1/y_0) \exp\left[(-1/N)\int_0^\tau \exp(-1/y_0)\, d\tau\right] \qquad (13)$$

Figure 1. Rate of Cure for First-Order Heat Release



Outer concentric regions

$$dy_i/d\tau = [(1 + 1/2i)\, y_{i+1} - 2y_i + (1 - 1/2i)\, y_{i-1}]/(\Delta\rho)^2 + c_1 \exp(-1/y_i) \exp\left[(-1/N)\int_0^{\tau} \exp(-1/y_i)\, d\tau\right] \quad (13a)$$

For convenience in programming, it is possible to use the following auxiliary equations to represent the heat-generation term for the i th element:

$$dn_i/d\tau = -\, n_i\, k_i \quad (14)$$

where n_i is the fractional amount of product remaining in the i th element, and k_i is a dimensionless reaction-rate constant

$$dk_i/d\tau = (1/y_i^2)\,(dy_i/d\tau) \quad (15)$$

In the case of zero-order heat release, completion of the reaction in each volume element is indicated when

$$\int_0^{\tau_f} \exp(-1/N)\, d\tau = \kappa/r_0^2 B_0 = N_0 \quad (16)$$

3. **Interpolation of Data**—Results of all calculations were summarized by recording the maximum temperature attained at the center of the medium and also the time at which the maximum temperature rise occurred. The time so chosen often corresponded to practically complete reaction. Accordingly a cooling curve corresponding to no heat release is frequently obtained after the maximum temperature rise. The data are summarized in Table I.

Equations have been derived empirically which express the maximum temperatures T_m attained and the curing times t_c as functions of the various parameters which enter into the problem. These equations are expressed in terms of the experimental variables and are restricted in the sense that one value (25° C) of the initial medium temperature applies over their range of applicability. This limitation is not serious for the T_m values since they are relatively insensitive variations in the initial medium temperature of ± 100 per cent. The curing time at an initial medium temperature other than that chosen can be calculated approximately by correcting for the time required for the temperature to change (by conduction alone) from one initial temperature to the other at the given surface temperature T. The derived equations are as follows:

Zero-order heat release

$$T_m = 62.2\, T_s^{0.31}\, (\kappa/r_0^2 B_0)^{0.027} + Q/\bar{c} - 3170/A^{1.52} \quad (17)$$

$$t_c = [30 \times 10^{0.208A}\, T_s^{-0.88}\, (\kappa/r_0^2 B_0)^{0.34} - 0.0022\, Q/\bar{c} + 0.066]\, r_0^2/\kappa \quad (18)$$

First-order heat release

$$T_m = 62.2\, T_s^{0.31}\, (\kappa/r_0^2 B_1)^{0.027} + Q/c - 1700/A^{1.2} \quad (19)$$

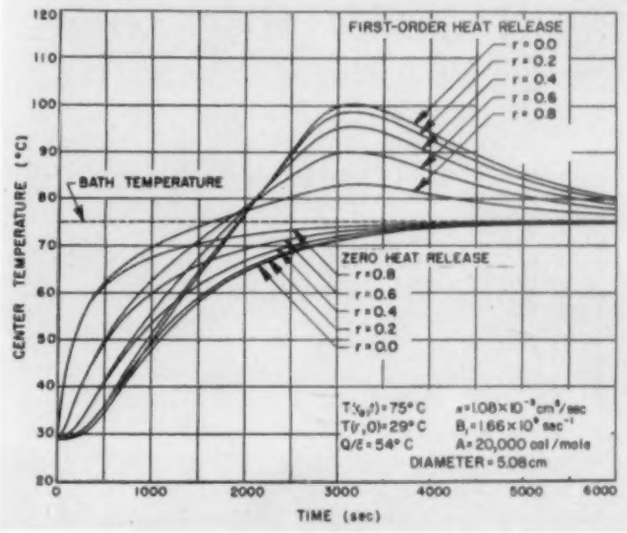
$$t_c = [45 \times 10^{0.2A}\, T_s^{-0.88}\, (\kappa/r_0^2 B_1)^{0.33} - 0.0031\, Q/\bar{c} + 0.093]\, r_0^2/\kappa \quad (20)$$

The average percentage differences of the values to T_m and t_c from the equations and machine calculations are as follows: T_m Eq. (17) — ± 7; T_m Eq. (19) — ± 5; t_c Eq. (18), A = 15, 20 kcal/mole — ± 6; t_c Eq. (18), A = 10 kcal/mole — ± 50; t_c Eq. (20), A = 15, 20 kcal/mole — ± 8; t_c Eq. (20), A = 10 kcal/mole — ± 50.

The wide discrepancy to t_c values obtained when the activation energy is 10 kcal/mole is partly due to the fact that the solutions of the differential equation have in these cases exceptionally broad maxima, and accordingly it was difficult to determine their position with respect to the time coordinate. Despite the approximate nature of the empirically derived formulas for T_m and t_c, it is believed that they will serve as a helpful guide in approaching an otherwise hopelessly complicated heat-transfer problem.

4. **Interpretation of Calculations**—In order to visualize immediately the results of machine calculations, numerous

Figure 2. Radial Temperature as Function of Time



All computations with the electronic differential analyzer were carried out by A. G. Presson with the assistance of Mrs. E. R. Napp.

TABLE I

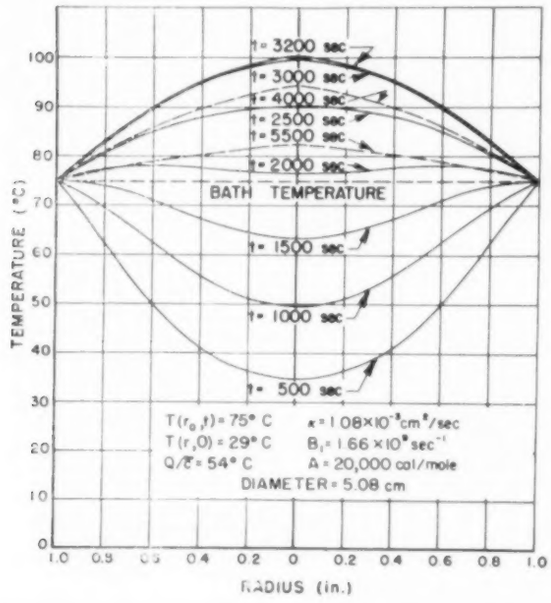
Summary of Machine Calculations For First-Order and Zero-Order Heat Releases

A	Q/E	N^{-f}	T_b	First Order		Zero Order	
				T_m	τ_c	T_m	τ_c
20	30	10^{14}	90	90.8	0.193	93.0	0.143
	↓	↓	75	85.4	0.235	91.2	0.172
	↓	↓	60	75.2	0.319	93.8	0.237
	50		90	108.6	0.150	107.2	0.096
	↓		75	105.2	0.175	99.2	0.122
	↓		60	98.4	0.237	114.5	0.173
	75		90	132.7	0.121		
	↓		75	130.2	0.140	119.2	0.111
	↓	↓	60	98.4	0.237	114.5	0.173
	30	3×10^{13}	90	98.8	0.273	108.2	0.212
	↓		75	89.0	0.358	106.8	0.282
	↓		60	71.2	0.540	93.6	0.416
	50		90	120.6	0.208	123.8	0.164
	↓		75	115.0	0.266	125.4	0.212
	↓		60	98.0	0.418	143.0	0.329
	75		90	145.3	0.165	138.2	0.134
	↓		75	141.8	0.215	147.4	0.165
	↓	↓	60	133.5	0.316	138.3	0.263
	30	10^{13}	90	100.2	0.418	111.8	0.319
	↓	↓	75	85.0	0.466	100.2	0.466
			60				
10	30	3×10^{7}	90	----	----	92.2	0.149
	↓		75	78.4	0.287	86.2	0.162
	↓		60	68.2	0.500	78.2	0.182
	50		90	100.6	0.190	125.1	0.118
	↓		75	93.4	0.203	117.0	0.126
	↓		60	83.7	0.225	109.0	0.143
	75		90	125.6	0.139	145.8	0.093
	↓		75	119.3	0.151	145.0	0.100
	↓	↓	60	109.6	0.170	142.2	0.111
	30	10^{7}	90	95.3	0.425	104.6	0.283
	↓		75	82.3	0.490	93.6	0.346
	↓		60	66.8	0.575	77.6	0.472
	50		90	107.8	0.330	129.6	0.250
	↓		75	93.9	0.395	116.6	0.277
	↓		60	75.8	0.482	100.2	0.362
	75		90	130.2	0.265	161.2	0.186
	↓		75	109.4	0.347	146.8	0.248
	↓	↓	60	93.0	0.408	131.2	0.286
15	75	3×10^{10}	90	144.6	0.174	165.8	
	↓	↓	75	136.6	0.213	151.0	
	↓	↓	60	119.0	0.291	159.0	
	30	10^{10}	90	98.2	0.415	105.0	0.292
	↓		75	84.2	0.528	93.2	0.386
	↓		60	65.8	----	75.0	0.650
	50		90	113.5	0.324	131.8	0.237
	↓		75	98.6	0.430	118.6	0.313
	↓		60	----	----	91.8	0.498
	75		90	144.4	0.252	167.0	
	↓		75	127.6	0.335	159.0	0.261
↓	↓	↓	60	95.4	0.540	127.6	0.408
10	30	10^{8}	90	----	----	69.6	0.073
	↓		75	----	----	68.0	0.075
	↓		60	63.6	0.103	64.4	0.077
	50		90	88.5	0.115	95.0	0.065
	↓		75	85.0	0.115	92.4	0.056
	↓		60	80.9	0.115	87.8	0.057
	75		90	110.1	0.093	113.2	0.043
	↓		75	107.9	0.091	116.2	0.044
↓	↓	↓	60	104.9	0.090	114.2	0.045
20	50	10^{13}	90	119.7	0.342	127.2	0.247
	↓	↓	75	103.3	0.462	130.0	0.350
	↓		60				
	75		90	140.7	0.273	154.4	0.180
	↓		75	132.9	0.350	161.8	0.272
↓	↓	↓	60				
15	30	10^{11}	90	86.6	0.195	105.4	0.136
	↓	↓	75	80.8	0.220	95.4	0.153
	↓	↓	60	72.2	0.268	88.0	0.186
	50		90	105.8	0.140		
	↓		75	102.1	0.156		
	↓		60	94.8	0.188		
	75		90	130.0	0.117		
	↓		75	129.4	0.123		
	↓	↓	60	124.2	0.145		
	30	3×10^{10}	90	95.0	0.300	107.9	0.217
	↓		75	84.4	0.370	98.6	0.268
	↓		60	69.4	0.500	85.6	0.379
	50		90	115.4	0.219	143.8	0.168
	↓		75	104.8	0.276	135.0	0.208
↓	↓	↓	60	86.6	0.395	119.2	0.289

curves covering a wide variety of conditions have been made directly in terms of the experimental quantities. These calculations were made early in the investigation, and various refinements used on the dimensionless variable calculations were not employed. Also, computing was done on only five elements. However, this number was adequate for the purpose of the present discussion. The most important factors involved in the curing process from the point of view of heat release are now discussed in terms of the calculated results.

A. **Temperature Rise vs Extent of Cure**—In Figure 1 a comparison is made of time required for various amounts of cure and the extent to which the center temperature has been raised by a combination of conduction and chemical reaction. A first-order, heat-release mechanism was

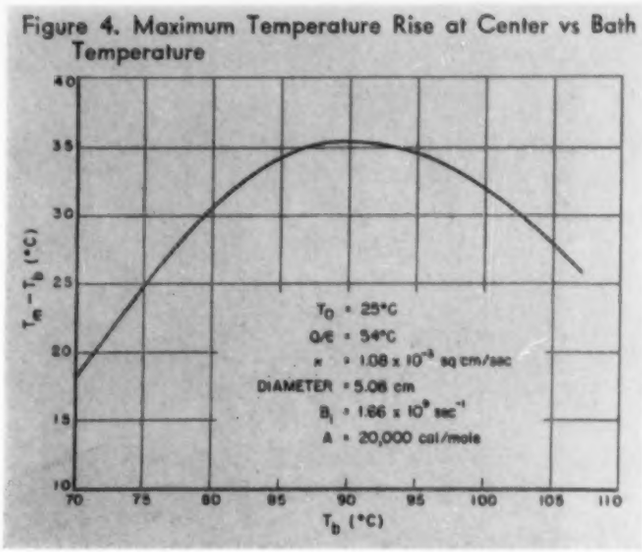
Figure 3. Temperature Distribution at Various Time Intervals for First-Order Heat Release



chosen, and the parameters used for the solution of equation (11) were as follows: T_{b_0} = 75°C; T_{a_0} = 25°C; Q/c = 54°C; $B_1 = 2 \times 10^9$ sec^{-1}; A = 20,000 cal/mole; K = 1.08×10^{-3} sq cm/sec; and diameter = 5.08 cm. For this set of parameters, it should be noted that about 90 per cent of the cure takes place in 3200 seconds, the approximate time required to reach the maximum temperature in the center. However, it must be emphasized that, although most of the cure takes place in a short period of time, many additional hours are often required for the last and important 10 per cent of cure, particularly when the bath temperature is low. Therefore, in practice where the highest bath temperature cannot always be used, actual curing periods required are often much longer than those discussed here.

B. **Radial Distribution of Temperature Throughout Cylinder While Curing**—The calculated radial distributions of temperature throughout a cylinder in the process of curing (Figs. 2 and 3) are taken from solutions of equations (11) using the following values: T_{b_0} = 75°C; T_{a_0} = 29°C; Q/c = 54°C; K = 1.08×10^{-3} sq cm/sec; diameter = 5.08 cm; $B_1 = 1.66 \times 10^9$ sec^{-1}; and A = 20,000 cal/mole. It is apparent

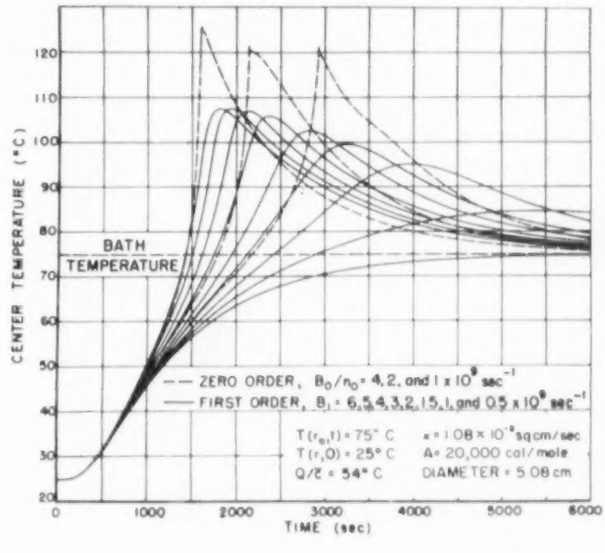
Figure 4. Maximum Temperature Rise at Center vs Bath Temperature

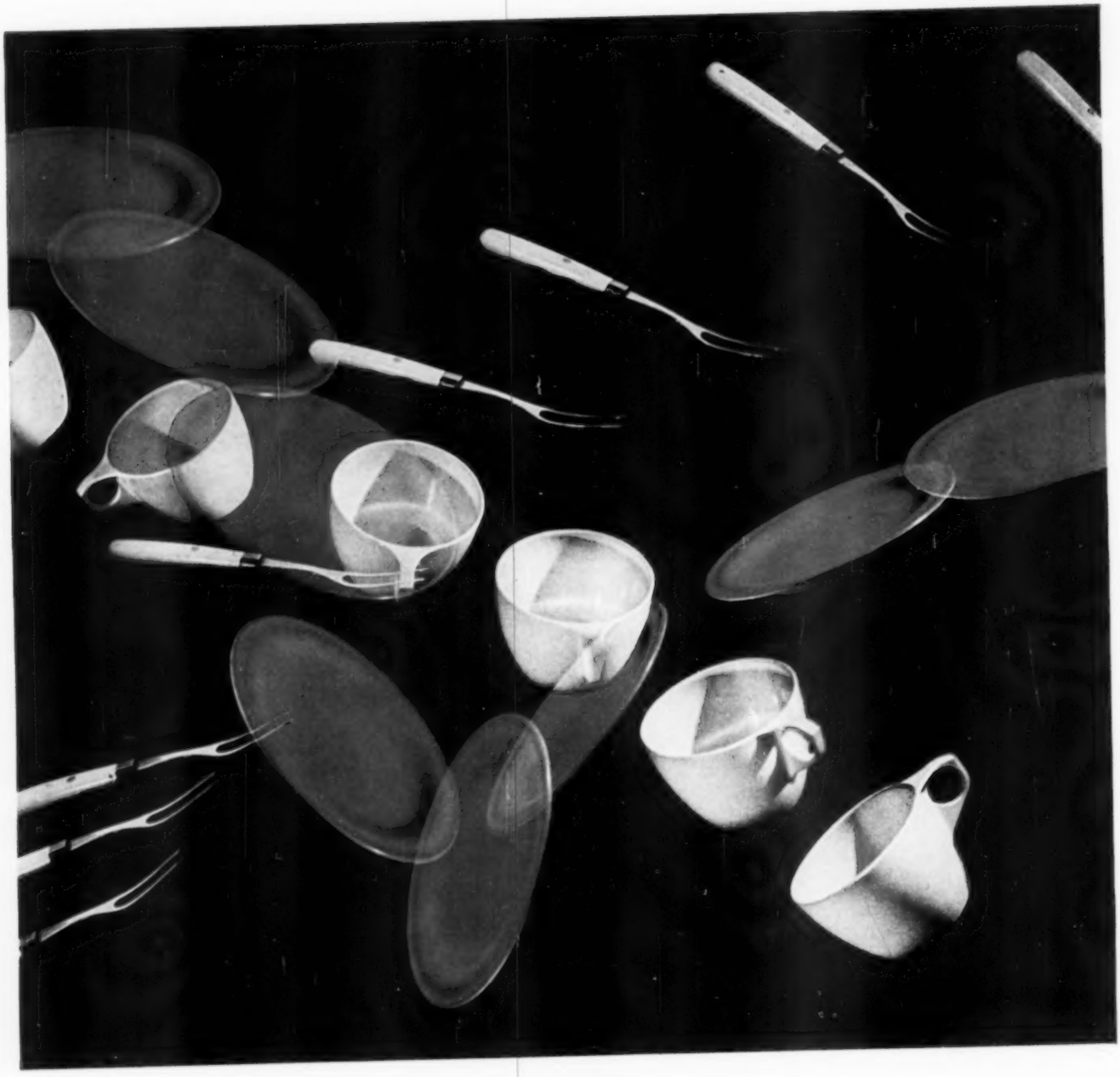


that cure along the radius takes place unevenly. The center is not the only place in which a maximum occurs in the radial-temperature distribution. The uneven character of the radial-temperature distribution has frequently been observed experimentally.

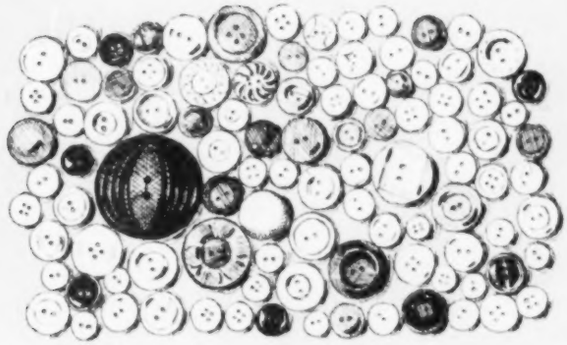
C. **Effect of Bath Temperature, Pre-Exponential Factor, Adiabatic-Temperature Rise (Q/c), and Initial Charge Temperature**—The effect of bath temperature on the maximum temperature reached at the center of a casting resin cylinder was obtained for first-order heat release (Eq. 11) using the following data: T_{b_0} = 70, 75, 80, 85, 90, 95, 100, and 105°C; T_{a_0} = 25°C; Q/c = 54°C; K = 1.08×10^{-3} sq cm/sec; diameter = 5.08 cm; $B_1 = 1.66 \times 10^9$ sec^{-1}; and A = 20,000 cal/mole. When the cylinder is cured at higher and higher bath temperatures, the center temperature increases at first and then levels off to a constant value. If the temperature rise above bath temperature is plotted against bath temperature, a curve with a maximum is obtained as shown in the calculated curve of Figure 4. This result agrees qualitatively with experimental findings. The variation to $T_m - T_b$ with T_b can be explained as follows: The initial rise

Figure 5. Effect of Varying Pre-Exponential Factor

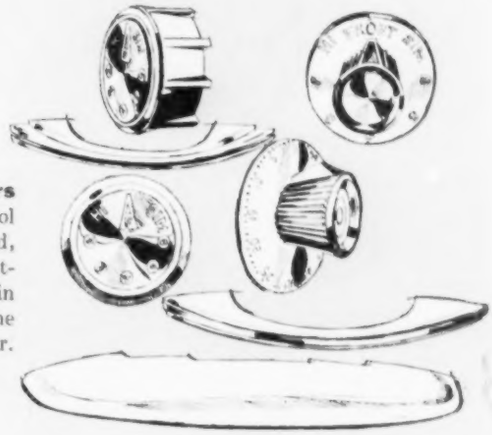

BATH TEMPERATURE
— — ZERO ORDER, B0/n0 = 4, 2, and 1 x 10⁹ sec⁻¹
—— FIRST ORDER, B1 = 6, 5, 4, 3, 2, 1.5, 1, and 0.5 x 10⁹ sec⁻¹
T(r0,t) = 75° C
T(r,0) = 25° C
Q/c = 54° C
x = 1.08 × 10⁻³ sq cm/sec
A = 20,000 cal/mole
DIAMETER = 5.08 cm
CENTER TEMPERATURE (°C)
TIME (sec)



Do you know the
facts about these
flying saucers?



The ruggedness and durability of these materials are vividly demonstrated in urea and melamine buttons. They are subjected to the punishment of continual torture tests . . . repeated washings in strong, soapy water, contact with hot irons and the abuse of everyday wear—yet they look sparkling new after years of service.



Stove manufacturers use PLASKON Urea for control knobs because it has a very hard, glossy surface and good heat-resistance. Urea is widely used in electrical appliances for the home because of its ability as an insulator.

PLASKON Melamine and, for that matter, Urea Molding Compounds have low moisture absorption. Because they are inert, odorless and tasteless, they're ideal for use in food and cosmetic containers and closures.

The bouncing dinnerware illustrated is molded of highly break-resistant PLASKON® Melamine. And the way this modern material has solved the problem of "flying saucers" may well show you how to put new life and bounce into the sale of products you produce for your customers.

Consider the life led by a piece of restaurant dinnerware. It's put to daily torture tests—subjected to the shock of piping hot beverages and abuse of the sizzling fat of fried or broiled foods, punished by cutlery and forced to withstand scalding water and detergents an average of seven times each day. — Or consider the service required of a button molded of PLASKON Melamine for use on military fatigue and combat clothing—abuse in every category, including high temperature pressure cleaning and sterilization. PLASKON Melamine Molding Compound meets these tests, remains bright, beautiful and serviceable long after ordinary dinnerware and buttons have broken, chipped, cracked or faded.

And the same enduring qualities—including unlimited color—which PLASKON Melamine lends to dinnerware and buttons are adding new sales-appeal and durability to many household appliances and industrial items. Wherever style, beauty and serviceability are vital product requisites, PLASKON Melamine could well be the answer.

For further information address BARRETT DIVISION, Allied Chemical & Dye Corporation, Dept 45K, 40 Rector St., New York 6, N. Y.

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Figure 6. Effect of Varying Q/c

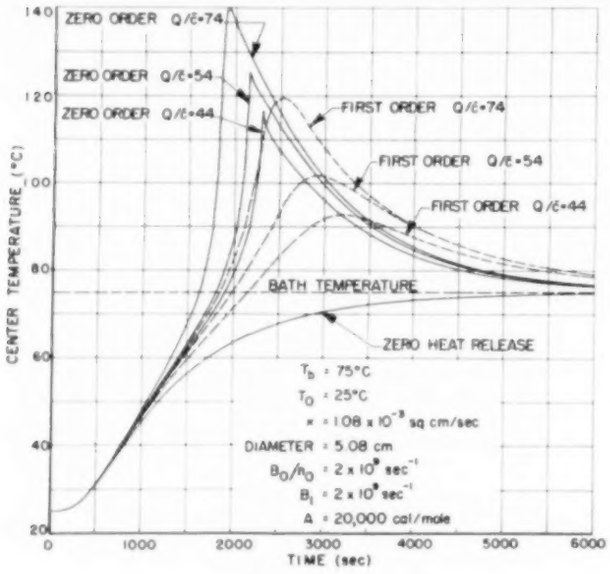
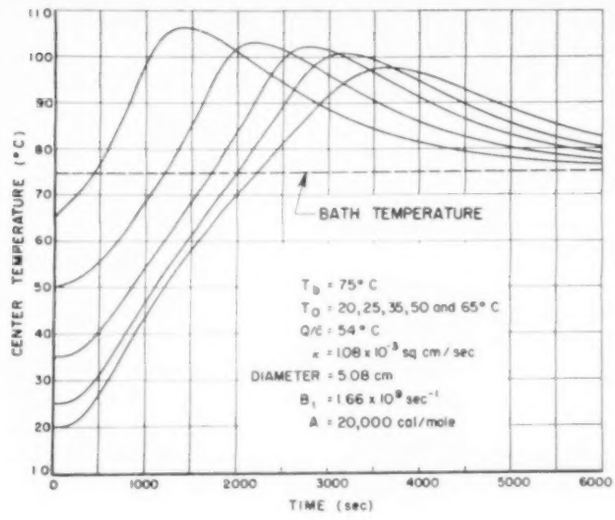


Figure 7. Effect of Varying Initial Resin Temperature


BATH TEMPERATURE
T_b = 75° C
T_0 = 20, 25, 35, 50 and 65° C
Q/c = 54° C
κ = 1.08 x 10^{-3} sq cm/sec
DIAMETER = 5.08 cm
B_1 = 1.66 x 10^9 sec^{-1}
A = 20,000 cal/mole
CENTER TEMPERATURE (°C)
TIME (sec)

is due to the fact that at first higher bath temperatures allow the rate of heat produced by chemical reaction to exceed that carried away by conduction. At the same time, more heat from chemical reaction is being used to raise the center to bath temperature so that eventually little heat remains to raise it above T_b.

In vinyl polymerizations the rate of reaction can be conveniently altered by varying the amount of peroxide catalyst added. Under certain conditions, for example, the initial rate of polymerization varies roughly as the square root of catalyst concentration. In Figure 5 several curves comparing zero-order and first-order polymerization are given. Calculations were based on the following constants: T_b = 75° C; T_0 = 25° C; Q/c = 54° C; K = 1.08 x 10^{-3} sq cm/sec; diameter = 5.08 cm; B_0/n_0 = 1, 2 and 4 x 10^9 sec^{-1}; B_1 = 0.5, 1, 1.5, 2, 3, 4, 5, and 6 x 10^9 sec^{-1}; and A = 20,000 cal/mole. It is apparent from the calculated results that a relatively small change in pre-exponential factor in terms of that realizable experimentally is required for large changes in cure. Therefore the pre-exponential factor offers one of the most convenient and effective means for control of the heat-release problem.

In Figure 6 a comparison of zero-order and first-order polymerizations for different values of Q/c is given. The following constants were used in the calculations: T_b = 75° C; T_0 = 25° C; Q/c = 44, 54, and 74° C; K = 1.08 x 10^{-3} sq cm/sec; diameter = 5.08 cm; B_0/n_0 = 2 x 10^9 sec^{-1}; B_1 = 2 x 10^9 sec^{-1}; and A = 20,000 cal/mole. Effects are similar to those observed with change in pre-exponential factor. It should be observed, however, that Q/c cannot be altered to the same degree as the pre-exponential factor.

In a number of early experiments, curing studies were made in which the initial temperature of casting resin varied considerably. Figure 7 demonstrates that the effect of T_0 on the maximum temperature attained at the center is relatively small. The most significant effect is the decrease in curing time resulting from the increase in initial casting resin temperature. Parameters used in the calculations were as follows: T_b = 75° C; T_0 = 20, 25, 35, 50, and 65° C; Q/c = 54° C; K = 1.08 x 10^{-3} sq cm/sec; diameter = 5.08 cm; B_1 = 1.66 x 10^9 sec^{-1}; and A = 20,000 cal/mole.

IV. Mechanical-Property Considerations

It has been suggested in section II that pot-life, shrinkage, etc., can be adjusted by the use of plasticizers and fillers. The addition of various materials to casting resins will naturally modify their mechanical properties, and it is necessary to know what type of modification is to be expected for a given additive. For this reason a general discussion of the mechanical behavior of casting resins

Figure 8. Linear Viscoelastic Elements

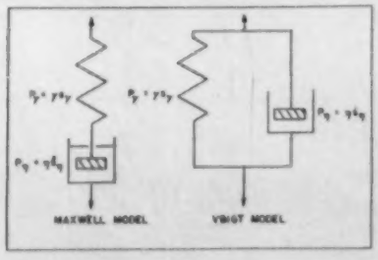
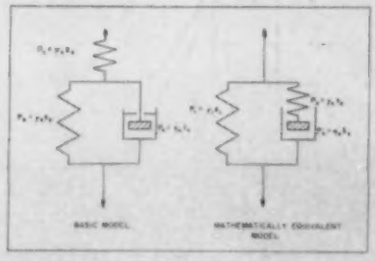


Figure 9. Generalized Maxwell Model



will be given. The discussion applies both to linear polymers and the cross-linked or thermosetting types. In general it appears that the thermosetting type of polymer is preferable for casting resins since (1) they show little or no secondary creep, (2) they are less sensitive to extent of reaction, (3) and the working life is sharply defined as a result of the characteristic sudden appearance of the gelation point. Solvent resistance and the infusibility characteristic of many of the thermosetting types of polymers are also advantages of the materials.

Picture of Mechanical Properties

If the casting resin is rubberlike, a good picture of its mechanical properties under conditions of equilibrium can be obtained by reference to the kinetic theory of rubber elasticity as described in Treloar's book (Cf. Ref. 7). It is possible, for example, to make satisfactory estimates of the static modulus on the basis of chemical composition provided the latter is known with sufficient exactitude. Dynamic and quasi-static behavior, however, can only be understood by resorting to more general theories of viscoelastic behavior, since it is the viscous processes which show such strong time and temperature dependence.

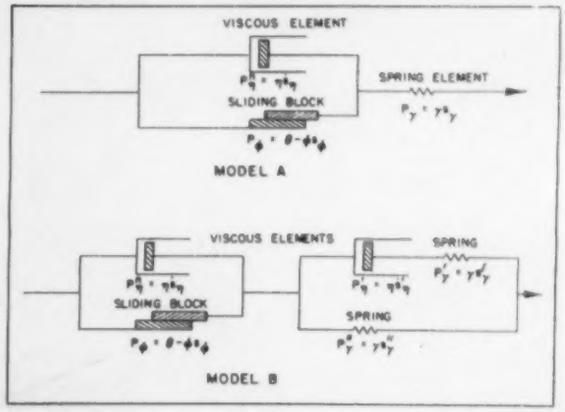
1. **Linear Viscoelastic Behavior**—The mechanical behavior of most casting resins can be understood in terms of the well-founded theory of linear viscoelastic behavior of polymers as discussed extensively by Alfrey (Cf. Ref. 8).

The phenomenological theory of linear viscoelasticity is based on the fact that the mechanical behavior of a material can be completely described by its representation as a continuous set of Maxwell elements arranged in parallel or a continuous set of Voigt elements arranged in series (Cf. Figure 8). Each element is assigned a relaxation time τ_i and a partial modulus λ_i. The springs are Hookean, and the dashpots are Newtonian. A given material is then defined either in terms of a distribution of relaxation times or a distribution of retardation times. The real power of this method of describing the mechanical properties of polymers lies in the following facts: (1) once a given property of the material such as a relaxation distribution function is known, all other types of mechanical behavior can be derived by straightforward mathematical transformations, and (2) reduced variable schemes can be devised which have significance in terms of the properties of the mechanical models and which allow the preparation of "master" plots over a wide range of temperature and time scale. These master plots as devised by Ferry (Cf. Ref. 9) and Tobolsky (Cf. Ref. 10) and their associates, e.g., provide a means of representing on a single curve essentially an infinite set of experiments conducted at different temperatures.

It is also of interest to note that recent molecular theories of viscoelasticity have made important strides in explaining the fictitious springs and dashpots in terms of modes of segmental motion of polymer chains (Cf. Ref. 11, 12). Although F. Bueche's theory (Cf. Ref. 11) provides a straightforward mathematical procedure for calculating various kinds of mechanical behavior in terms of his proposed model, it appears that Rouse's theory (Cf. Ref. 12) provides the most fundamental approach to the problem of understanding viscoelasticity on a molecular scale. Several other theories have been advanced but they appear to be less suggestive physically than the two cited.

2. **Filled Rubbers and Plastics**—Although the theory of viscoelasticity of polymers has reached a highly developed state, the theory of filled systems has been given relatively little attention. Therefore, instead of merely reviewing what knowledge is available on these systems, a somewhat more detailed discussion of their properties will be undertaken.

Figure 10. Mechanical Analogies for Correlating Viscoelastic Behavior of Composite Materials



One of the most important distinctions to be made in discussing filled rubbers or plastics* is whether or not the resin adheres to the filler. When adhesion is not present, the filled material behaves essentially as a "diluted" resin in that the modulus and ultimate elongation of the material are reduced in proportion to the volume fraction of filler present, and the filled resin can be described in terms of its viscoelastic behavior. At extremely high filler loading there is a departure from this simple behavior, i.e., at a loading near close-packing for the filler particles. When adhesion is present, the filled material shows a strong reinforcing effect with respect to modulus, and the ultimate elongation is usually significantly lower.

In a highly filled material possessing particle-binder adhesion, the mechanical properties differ considerably from the usual linear viscoelastic behavior. Conclusions based on admittedly scanty experimental evidence suggest that the stress-strain behavior is somewhat irreversible, and the strain rate dependence is not consistent with Newtonian viscous processes. In fact, stress-strain data on an epoxide resin containing about seventy per cent filler could only be correlated by use of a rather unconventional mechanical model. The model,* however, incorporates features which can be assigned physical meaning in terms of a composite material and for this reason will be presented.

In examining the stress-strain data of a filled epoxide resin, the model was derived in the following manner. Some critical stress value seemed necessary to account for so-called "dry friction," and this stress must decrease linearly with strain after the element is in operation. The element chosen was that of two blocks held together by a pressure (Θ). The area over which this pressure is applied diminishes linearly as the blocks are separated. This element was placed in parallel with a dashpot exhibiting Newtonian viscosity, and the two parallel elements were placed in series with a spring obeying Hooke's law. The

The reinforcing effect of carbon black on rubber will not be included in this discussion. Rehner (Cf. Ref. 16), A.M. Bueche, and others have discussed the theory of this type of reinforcement, and it is likely that it takes place on a molecular scale. Filler effects discussed herein are essentially of macroscopic origin.

The devised model and accompanying calculations were part of a separate collaborative effort of the author with Mr. Robert Nathan.

resulting linear model (model A in Figure 10) was then similar to the basic model (Fig. 9) in which the spring parallel to the dashpot is replaced by the sliding block. Since the dashpot is considered Newtonian, the power of n of P is equal to 1. It is possible to write solutions of model A (Fig. 10) for a constant rate of strain process as follows:

$$P = \gamma_s \quad ; \quad P \leq \theta \tag{21}$$

$$P = \theta + \eta k \left[\gamma/(\phi - \gamma)\right]^2 \{1 - \exp\left[(\phi - \gamma)(s - s_\theta)/\eta k\right]\}$$

$$+ \gamma\phi (s - s_\theta)/(\phi - \gamma) \quad ; \quad P > \theta \tag{22}$$

where P = Stress based upon the original cross section of the specimen
k = constant strain rate
γ = Hooke's law constant
η = viscosity coefficient
s = strain; s_θ = strain when $P = \theta$
ϕ = proportionality constant for sliding block

Solving for the values of P_{max} and $s_{P_{max}}$ (i.e., setting $dP/ds = 0$) gives the three relations,

$$\phi = \gamma \exp\left[(\phi - \gamma)(s_{p\ max} - s_\theta)/\eta k\right] \tag{23}$$

$$\eta = \left[\gamma\phi (s_{p\ max} - s_\theta) - (\phi - \gamma)(P_{max} - \theta)\right]/\gamma k \tag{24}$$

$$P_{max} = \theta + (\theta - \gamma s_{p\ max})\left[1/ln\ (\phi/\gamma) + \phi/(\gamma - \phi)\right] \tag{25}$$

Using these three relations, an attempt was made to correlate stress-strain data of a sample of filled epoxide resin at several different loading rates. It was found that reasonable agreement (Cf. Fig. 11) could be obtained, however, only when both θ and η were made functions of k. The agreement between results obtained experimentally and

Figure 11. Test of Linear Model at Different Loading Rates

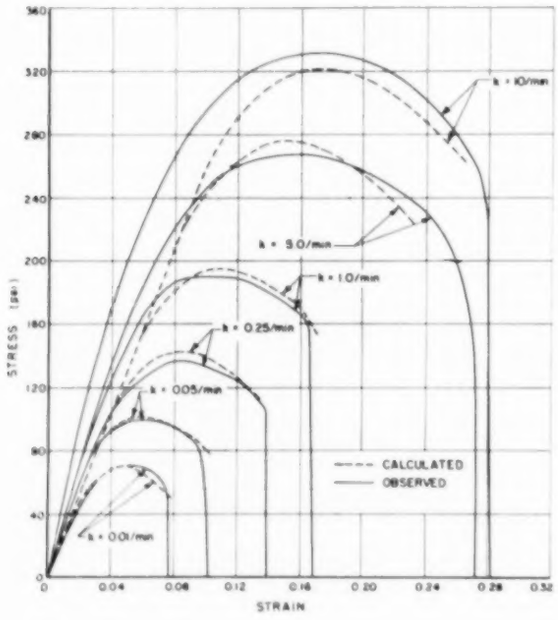
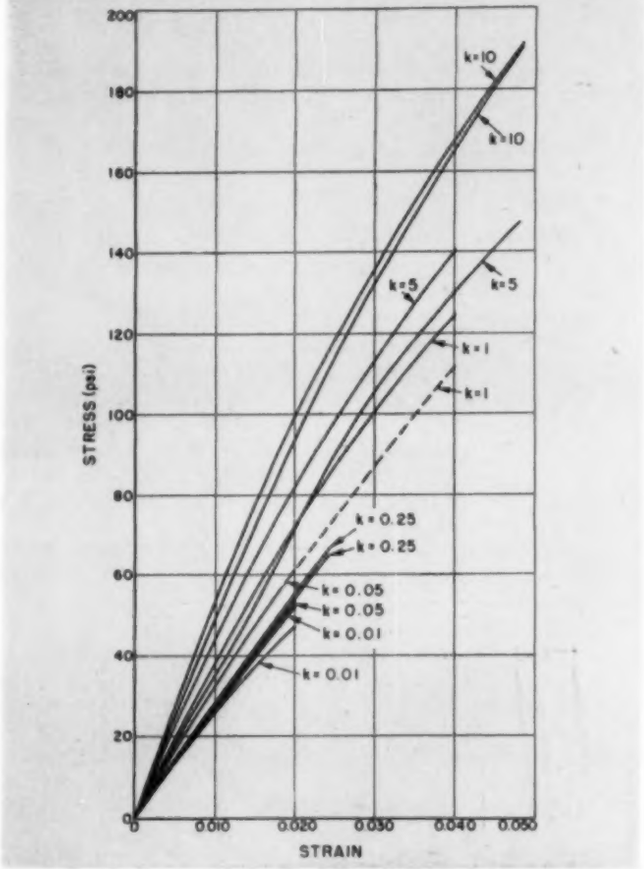


Figure 12. Variation of Initial Slope with Refined Model

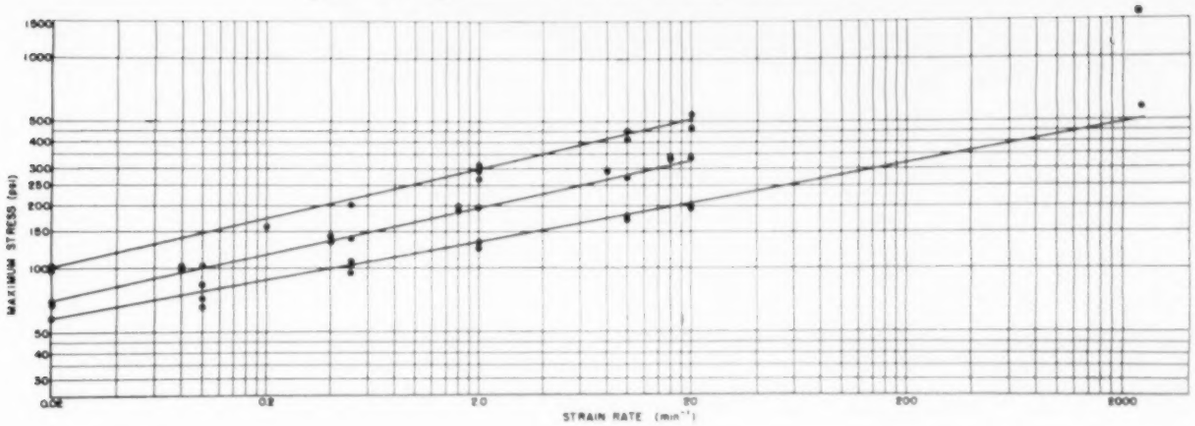


those calculated from model A in Figure 10 (n = 1) can be improved considerably by employing a model like model B in Figure 10 (n = 1). A demonstration of how the initial slope can be made to vary with strain rate by use of model B is given in Figure 12, in which two sets of approximations to the spring constants and the viscosity coefficient are shown.

The particular functional relationship required for θ was extremely suggestive. It had been observed that this parameter was primarily responsible for determining the maximum stress observed in stress-strain curves. Empirically it had been found that a plot of the logarithm of the strain rate vs the logarithm of the maximum stress for the filled epoxide resin was linear over five cycles of logarithms (to strain rates as high as 2000 min $^{-1}$) as in Figure 13, where data on three different compositions are shown. The exponential relationship between strain rate and maximum stress directed attention to the possibility of using a power law to express the non-Newtonian behavior of the dashpot; i.e., the nth power of the shearing stress is proportional to the rate of flow, the proportionality constant being the usual viscosity coefficient. There has been wide use of power laws in correlating flow behavior, particularly in dealing with composite materials (Refs. 13 and 14). Although the power n has no exact physical meaning, it is believed to express the capacity of the particle aggregates (in the composite medium) to be deformed or oriented.

It might also be mentioned that the sliding-block element is a modification of the St. Venant body (Ref. 13). The modification differs only in that, after a stress is

Figure 13. Log Maximum Stress vs Log Strain Rate



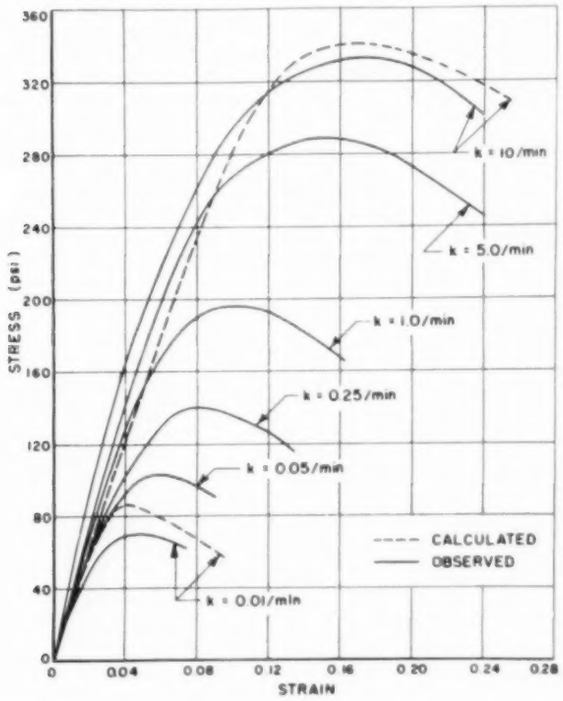
reached at which flow having a constant force begins, the force decreases linearly with the strain of the element. The well-known Bingham body also employs the idea of a sliding block, and the general idea of the power law of flow is brought to mind by the de Waele-Bingham law of flow for composite fluids (Cf. Ref. 14)

$$\dot{s} = (P - \theta)^n/\eta \qquad (26)$$

The friction elements (sliding block and power-law dashpot) taken together have physical significance in the fact that the resin adheres to the solid particles; the structural reinforcement due to such adhesion may be represented by sliding friction, which produces a characteristic maximum in the stress-strain curve.

In order to obtain stress-strain curves at different loading rates corresponding to model A in Figure 10, it was necessary to solve the following equations:

Figure 14. Test of Nonlinear Model at Different Loading Rates



$$P = P_\gamma = \gamma s_\gamma = \gamma s \quad ; \quad P \leq \theta \qquad (27)$$

$$dP_\eta/ds = (1/k)(dP_\eta/dt) = \gamma + P_\eta^n(\phi - \gamma)/k_\eta \quad ; \quad P > \theta \qquad (28)$$

$$dP_\phi/ds = -\phi P_\eta^n/k\eta \quad ; \quad P > \theta \qquad (29)$$

$$P = P_\eta + P_\phi \qquad (30)$$

$$s = s_\gamma + s_\phi \qquad (31)$$

$$P_\eta(0) = 0 \qquad (32)$$

where P is the total stress on the system, s the total strain on the system, P sub γ the stress on the spring element, s sub γ the strain on the spring element, θ the proportionally constant for the sliding block, P sub η the stress on the viscous element, and η the viscosity coefficient of the nonlinear viscous element. Equation (27) is determining until P becomes greater than θ; then a simultaneous solution of equations (28) and (29) is required, using the boundary conditions:

$$P = \theta$$

$$s = s_\rho = \theta/\gamma$$

$$(dP_\eta/ds)_{s=s_\rho} = \gamma$$

$$(dP_\phi/ds)_{s=s_\rho} = 0$$

Graphical solutions of these equations are compared with experimental data in Figure 14. Again the initial slope requires improvement, and the use of model B of Figure 10 is indicated.

A group of numerical solutions in dimensionless vari-

able form was computed for model A. For purposes of computation, values of $\phi = 500$ psi, $\gamma = 2600$ psi, $n = 4.6$, $\theta = 31.5$ were chosen. Equations (28) and (29) were then placed in the form shown in the following equations:

$$dP_\eta/d\xi = 26/3 - 630N\,(P_\eta/400)^n \qquad (33)$$

$$dP_\phi/d\xi = -\,150N\,(P_\eta/400)^n \qquad (34)$$

where $N = 400^n/90\ k\eta$, and $\xi = 300$ s. In Figure 15 solutions for several values of N are shown in which the ordinate is P = P sub η + P sub ϕ, and the abscissa is s = s sub ϕ + s sub γ. The solutions start at the point where the sliding-block element begins to move (P = θ = 31.5 psi). The solution prior to this point is readily calculated from equation (27). Solutions were stopped at points indicated by the dashed line. At these points the relation $\theta = \phi$ s sub θ holds, and the sliding block no longer contributes to the stress. An entirely unexpected and highly interesting feature came out of comparing such solutions of the differential equations with the experimental data. It was found that the ultimate elongation was closely approximated by the condition $\theta = \phi$ s sub θ. Further investigation of this point is desirable.

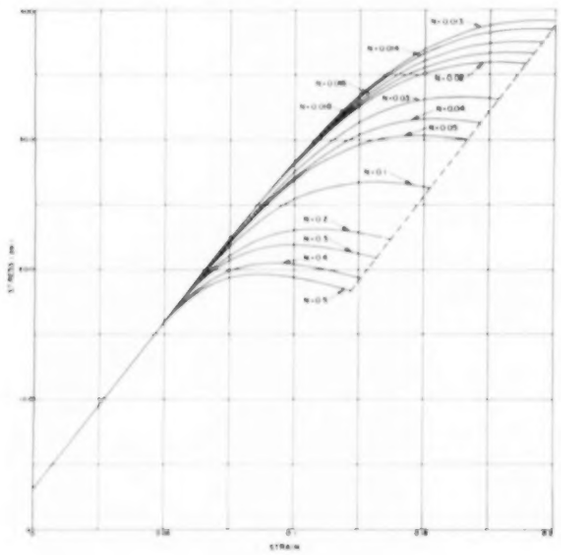
A rapid insight into the nature of the solutions in Figure 15 is obtained by examining the equation for the slope of the stress-strain curve as follows:

$$dP/ds = 2600\,[\,1 - 90N\,P_\eta^n/400^n\,] \qquad (35)$$

For example, at the point where the sliding block starts moving, Pη = O, and dP/ds = 2600 psi, as is evident from the curves of Figure 15. Also, the larger the N value, the lower the value at which the curve breaks away from the linear relationship. At the point on the curves where dP/ds = O, it is possible to determine P^n sub η or η s sub η. When N approaches zero, the quantity dP/ds approaches the constant value of 2600 psi. From the definition of N it is apparent, therefore, that dP/ds can be made to approach a constant value by increasing the strain rate k or the dashpot viscosity coefficient η. For the particular value of θ chosen, the substitution of P for P sub η in equation (35) gives a reasonably good approximation of the behavior shown in the curves of Figure 15. At low temperatures η is increased since it has been confirmed experimentally that the stress-strain curve is a straight line under these conditions (Cf. Ref. 15).

An important test of the general utility of the proposed model will be to determine the extent to which it can be used to predict quantitatively the effect of temperature changes on stress-strain properties of composite materials. Such studies are in progress.

Figure 15. Dimensionless Variable Solutions for Model A of Figure 10



V. Conclusions

Much information is available upon which the control of chemical and physical factors in application of casting resins can be based. Several areas remain in which further information would be desirable, viz., (1) more detailed kinetic data on the basic types of material now employed in commercially available resins, (2) accurate heat of polymerization data, (3) systematic heat-transfer calculations for several basic geometrical forms including chemical heat sources, and (4) the mechanical properties and rheological behavior of filled systems.

Bibliography

1. Flory, P. J., "Principles of Polymer Chemistry." Ithaca (N. Y.): Cornell University Press, 1953.
2. Gilman, H., "Organic Chemistry," Vol. II, pp 1741-1749. New York, N. Y., John Wiley & Sons, Inc., 1943.
3. Schildknect, C. E., "Vinyl and Related Polymers," page 231, New York, N. Y., John Wiley & Sons, Inc., 1952.
4. Nichols, P. L., Jr. and Presson, A. G., "Heat Conduction in an Infinite Cylindrical Medium with Heat Generated by a Chemical Reaction," Journal of Applied Physics, 25 No. 12, 1469-1472, (1954).
5. Seeger, R. J., "Proceedings of Symposium on Large Scale Digital Calculating Machinery," pp 157-168. Harvard University, Cambridge (Mass.) 1948.
6. Carslaw, H. S., and Jaeger, J. C., "Conduction of Heat in Solids." Clarendon Press, Oxford, 1947.
7. Treloar, L. R. G., "Physics of Rubber Elasticity," Oxford (Eng.): Clarendon Press, 1949.
8. Alfrey, T., Jr., "Mechanical Behavior of High Polymers," Vol. 6, N. Y.: Interscience Publishers, Inc., 1948.
9. Ferry, J. D., "Mechanical Properties of Substances of High Molecular Weight," Journal of the American Chemical Society, 72, 3746 (1950).
10. Tobolsky, A. V., Journal of the American Chemical Society, 74, 3786 (1952).
11. Bueche, F., "The Viscoelastic Properties of Plastics," Journal of Chemical Physics, 22, 603-609 (1954).
12. Rouse, P. E., "A Theory of the Linear Viscoelastic Properties of Dilute Solutions of Coiling Polymers," J. Chem. Phys., 21, 1272-1280 (1953).
13. Reiner, Markus, "Deformation and Flow," H. K. Lewis & Co., 1949.
14. "Adhesion and Adhesives" edited by N. A. DeBruyne and R. Houwink. New York; Elsevier Press, 1951.
15. Combined Bimonthly Summary No. 40 (December 20, 1953-February 20, 1954). Pasadena: Jet Propulsion Laboratory, March 20, 1954 (Confidential).
16. Rehner, J., Jr., "Thermodynamics and Mechanics of Filler Reinforcement," Journal of Polymer Science, 7, 519-536 (1951).

Plastics Research Institute—Netherlands

After its official establishment in September 1946 the Plastics Research Institute T.N.O. now has gone through ten years of continuous rapid expansion. Ten years in which this relatively young institute clearly proved its right of existence and became one of the largest departments of the well-known Central National Council for Applied Scientific Research (T.N.O.) in the Netherlands.

Having started its activities with a staff of about 10 people the institute at present employs nearly 180 people, including some 20 graduates. In fact the total number of T.N.O. employees working on plastics runs even higher, because in the Central Laboratory T.N.O. about 55 persons are engaged in basic research in the field of high polymers; this Central Laboratory originated from the Scientific Department of the Plastics Research Institute, T.N.O. and was converted into an independent central research institute approximately 2 years ago.

The activities of the Plastics Research Institute T.N.O. of course are directed primarily to the Dutch plastics industry which it serves as a center of information, as a consuling body and occasionally even as an extension of its research facilities. For ultimate performance of these various tasks however an intensive contact with foreign manufacturers and organizations dealing with plastics is of great importance.

Ranking first among the several departments of the institute is the Technological Department which is carrying out research sponsored by the industry as well as its own research in the field of materials and processing methods. Indispensable aid in doing this work is obtained from the laboratory and well-equipped pilot plant, both belonging to this department.

Also linked to the above department is a newly established **reinforced plastics pilot plant** in which quite a lot of development work is being carried out. The know-how here obtained is made available to contributing firms, enabling them to start commercial scale production if justified.

Another important place in the institute is taken by the Information & Documentation Department which employs a number of well-experienced people gathering and giving general information on any aspect of the processing, application and availability of plastics and related materials. Also the editorship of the Dutch periodical "Plastica" and the organization of excursions, courses and lectures of any kind comes under this department.

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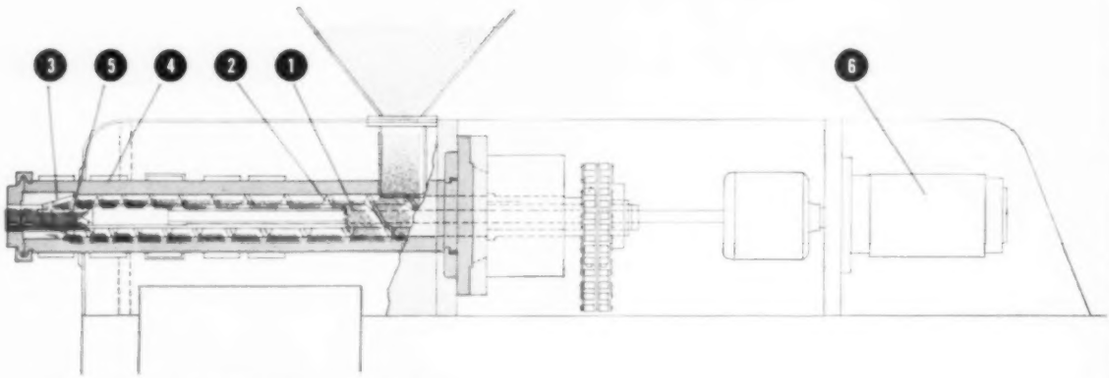

Here's How The *AUTOFLOW* Works:

Material feeds from the hopper into the screw barrel **(1).** Flights on the hollow screw **(2)** convey it forward to the heated cone baffle **(3).** Heating elements **(4)** are mounted on only a small forward section of the screw barrel. Material is plasticized by the mulling action of the tapered flights on the front of the screw against the heater cone baffle. Material extrudes internally through a series of ports (shown at the front of the screw) into a cavity ahead of the plunger **(5)** and out through the die.

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SOCIETY OF PLASTICS ENGINEERS, INC.

Mr. Jas. R. Davidson, Executive Secretary
Society of Plastics Engineers, Inc.
Greenwich, Connecticut

Dear Jim:

You better than anyone else have an understanding of the forming of new sections at the local level and what they can do to expand the Society of Plastics Engineers, being one of the organizers of the Kentuckiana Section and its first National Councilman.

During the past few years there have been nine such groups of men in local areas that forged the needed link between men with interest in plastics and our SPE which has been bonding such groups into the National Organization, to promote in all lawful ways the arts, sciences and engineering practices and standards connected with the utilization of plastics.

Many of our members who are in non-section areas would be amazed at the interest in their areas. Such interest warrants an active growing section which would be the motivating force in attracting speakers of technical eminence to their meetings, thus enabling this group to have personal contact with the speakers and others in their own industry. Members have been known to travel two hundred miles to attend local Section Meetings reaping rich rewards of knowledge and keeping abreast of developments during the interim periods between the Annual Technical Conferences held by the Society of Plastics Engineers.

With our Society now beyond the 5,000 members total do you realize that more than 10% of those members are in new sections? Your records will show them to be:

Central Indiana	89	Milwaukee	72	Pioneer Valley	82
Kansas City	64	Osaka	11	Pittsburgh	65
Kentuckiana	48	Pacific Northwest	38	Southern	74

These figures were taken from your membership report of September 30, 1956. It is of further interest to note that 25% of the new member applications in process are from these New Sections.

As you know, on September 21st sixty-seven men met in Binghamton, New York in their first technical dinner meeting which followed a twelve man steering committee meeting held August 24th. This committee was headed by Frank Reynolds and worked under the guidance of the New Section Development Chairman. President Formo spoke before these sixty-seven men on the history, objectives and future plans of SPE. These meetings have resulted in a petition for a charter for the Binghamton Section of SPE which will be presented at the National Council Meeting in January in St. Louis. These sixty-seven men are now hard at work building an active section of SPE.

Bear in mind that each of these new sections resulted from a need that was recognized by a few men who then organized the necessary group of nine members with the result of their efforts being a rewarding interchange of information within their new section.

My work on this committee has been gratifying and the enthusiastic support of all of these new sections has been most rewarding.

Cordially yours,

J. P. Healey
Chairman of the New Sections
Development Committee

15 Years of Plastics Progress

The 13th SPE Technical Conference

January 16, 17, 18 St. Louis

The Sheraton-Jefferson Hotel

Registration in Advance
Will Save You Time
See Page 5

A total of sixty papers, detailing the latest developments in the plastics industry, will be delivered at the annual conference of the Society of Plastics Engineers to be held in St. Louis on January 16, 17 and 18, 1957. The theme of the conference is "Fifteen Years of Plastics Progress."

The papers will be presented in a total of five sessions to be held at the large Sheraton-Jefferson Hotel in downtown St. Louis. The Sheraton-Jefferson Hotel is one of the finest hotels in the nation especially equipped to handle huge national conferences.

The conference committee, under the direction of Otto Wulfert, Wagner Electric Corp., St. Louis, has promised that ALL advance registrations will be handled with the utmost care and ALL RESERVATIONS WILL BE GUARANTEED by the committee. However, Wulfert urged that reservations be made now so as to "get the best."

Conference Speakers' Chairman B. M. Coons (Dow Chemical Co.) has obtained one of the most impressive lists of technicians to deliver papers at the conference. There are specialists in every field with something to interest every person attending the conference.

Listed below are some of the selected highlights of the sessions:

As timely as today's headlines is the "Atomic Session" which will have David Balantine, Brookhaven Laboratories, as moderator. In this session, J. O. Turner, California University, will talk on "Some Vital Roles of Plastics in High Energy Nuclear Research." Four men from the United States Naval Ordnance Laboratory have collaborated on a paper entitled: "The Corrosivities of Plastics and Rubbers," with H. A. Perry, Jr. listed as the author.

The session on "Compression Molding" will have Edward F. Borro, Sr. of Brookhaven Laboratories as moderator with John G. Green, Jr., E. I. duPont de Nemours & Co., speaking on "Synthetic Fiber Reinforcement of Thermosetting Resin Laminates." John L. Hull of the Hull-Standard Corp. will lead a discussion on "A Fully Automatic Transfer Molding Machine."

R. B. Akin of the duPont Co. will be moderator of the "Design" session which will be highlighted by a paper entitled: "Plastics — An Answer for Industrial Design" by R. Hughes of the Emerson Electric Manufacturing Co. Also spotlighting the "Design" session will be Edward Farrari's "From Appearance Design to Prototype Model." He is with the General Electric Co.

New developments in foams will be a feature of that session which will have Arnold Varner, General Electric Co., as moderator. R. N. Kennedy of the Dow Chemical Co. will speak on "Polystyrene — A Versatile Foaming Material" with G. R. Franson as co-author. "Use and Application of Isocyanate Foams" will be a paper delivered by Benjamin S. Collins of the Nopco Chemical Co.

Injection Molding will be featured in two sessions. James W. Flynn of the Celanese Corp. of America will speak on "The Molding of Linear Type Polyethylene" and F. M. Chapman of E. I. duPont will entitle his paper "Molding of 'Teflon' Tetrofluoroethylene Resin." These will be a part of the first Injection Molding Session.

Gordon Thayer of the Dow Chemical Co. will pilot the second session on Injection Molding. Of high interest will be Bryce Maxwell's "A Discussion of Bulk Compressability of Polymers and Effect of This Compressability on the Flow Properties." Maxwell is from Princeton University.

Don C. Walley of KSH will lead the "Instrumentation" session. C. E. Beyer of Dow Chemical Co. will talk on "Pressure Control for Injection Molding Machines" and other late instrumentation developments will be forthcoming in Richard K. West's "Advantages of Dual Thermocouples in Injection Cylinders and Extruder Barrels." West hails from the West Instrument Corp.

"Property-Structure Relationships in Polyethylene" by H. M. Spurlin with W. O. Brocken as co-author will be presented in the "Polyethylene Session." Spurlin is with the Hercules Powder Co. Of high interest in this session will be the paper "A Method of Evaluation of Polyethylene Molding Compounds."

There will be two sessions on "Reinforced Plastics." In the first session there are two papers bound to stir interest. They are: "Commercial Applications of 'B' Stage Preimpregnated Material vs. Wet Laying Systems" by S. G. Salzinger of the Coast Manufacturing Co. and "Molding Thick Glass-Reinforced Polyester Laminates" by F. Claudi Magnussen of the Hooker Electrochemical Co.

S. G. Salzinger will deliver another paper in the second session of "Reinforced Plastics." This time he will talk on "Development of High Temperature Resin Glass Systems." M. S. Ziegler of the E. I. duPont Co. will speak on "'Lucite' Acrylic Resin Syrup for Reinforced Structures" with A. Stockfleth as co-author. John Bjorksten and Risto P. Lappale of the Bjorksten Research Laboratories have collaborated on a paper entitled: "Extreme Strength Reinforced Plastic Film Systems." Frank W. Sheffler of the Lunn Laminates Co. will also talk on "Estimating in Reinforced Plastics."

Islyn Thomas of the Newark Die Co. will head the "Tooling and Machinery Session." B. Nathonson of the Monsanto Chemical Co. will speak on "Materials, Tooling and Machines for Injection Molded Packaging" and W. J. B. Stokes, II, of the Electromold Corp. will deliver a paper on "The Engineering of Molds Utilizing Electroformed Cavities."

The session on "Application" will have Dr. Albert

Lightbody as moderator. Two papers of interest will be "Vinyl Clad Steel" by Glenn E. Wintermute of Arvin Industries and "Stability of Nylon Parts in Business Machines" by Byron W. Nelson of the National Cash Register Co.

President Jerome Formo takes the stand to head the "Epoxy Session." Jerry hails from the Minneapolis Honeywell Co. Much interest will be shown in P. E. Ritt's paper "Epoxy Encapsulation of Transistor Flip Flops." Co-author is R. F. Marshall. Alon J. Breslan and Earl H. Sorg will present "Polysulfide Liquid Polymer Epoxy Resin Compounds in Plastic Tooling Applications." They hail from the Thiokol Chemical Corp.

There will be two "Extrusion" sessions. Clem Young from Crescent Plastics will head the first with papers by B. H. Maddock, Bakelite Co., "Factors Affecting Quality in Polyethylene" and "Effect of Blowup Ratio on Blown Polyethylene Film Properties" as interest compellers.

In the second "Extrusion" session, George Prall of Western Textile Co. will be moderator. K. G. Toll of E. I. duPont will speak on "Shape Extrusion Studies of 'Zytel' Nylon Resin" and R. K. Multer of Marbon Chemical Co. will talk on "Rigid Thermoplastics Piping (Cycolac)."

The Conference Committee has pointed out that the above mentioned papers and their authors are just a few of the important highlights of the forthcoming conference. The complete list of papers and authors will be published in the SPE Journal and can be obtained from the National Office.

Mayor Raymond R. Tucker of St. Louis, a former professor of engineering at Washington University (St. Louis), will welcome delegates to the conference at the noon luncheon. His talk, comments and interest will be a conference highlight.

A special ladies' program with a fashion show and sightseeing tour has been arranged. Joseph Holland, St. Louis civic leader and unofficial toastmaster of the town, will speak at the dinner. This will be preceeded by a cocktail party. There will be a pre conference smoker a day before the sessions officially open. The Prize Committee will have many interesting and unusual prizes to offer.

All in all, this year's conference in St. Louis is stacking up as one of the largest and most interesting in the Society's history. Make plans to meet in St. Looie in January, 1957.

SPE Officers Meet in St. Louis

OFFICERS AND MEMBERS of the National Council, Society of Plastics Engineers pictured at a meeting in September at the Sheraton-Jefferson Hotel in downtown St. Louis where the 1957 SPE Conference will be held. First row, from left: Jim Davidson, National Executive Secretary; Jesse H. Day, Editor SPE Journal; Wayne I. Pribble, Treasurer; J. W. Lindau III, Vice President; Jerry L. Formo, President; Peter W. Simmons, Secretary; Ernest P. Moslo, Director, Cleveland-Akron area. Standing, from left: A. M. Varner, Kentuckiana Section; G. W. Martin, Western New England Section; E. C. Quear, Central Indiana; R. W. Beckwith, Eastern New England; Irvin Wolock, Baltimore-Washington; Ken Gossett, Chicago; C. H. Whitlock, 1958 Conference Chairman Detroit; E. C. Bernhardt, Philadelphia; Joseph B. Schmitt, Pittsburgh; W. P. Bussart, St. Louis; H. S. Nathan, Buffalo; Byron W. Nelson, Miami Valley-Ohio; G. P. Humphrey, New York Section; Fred C. Sutro Jr., Kansas City; Roy A. Smith, Detroit.

The Technical Conference Committee

ENTIRE ST. LOUIS 1957 CONFERENCE COMMITTEE pictured with SPE President Jerry Formo and SPE National Executive Secretary Jim Davidson during a meeting of the St. Louis Section in September. Seated from left: Dan Otto, Chairman Publicity Committee; Walter P. Bussart, Secretary; Otto Wulfert, General Chairman, Formo; George Prall, President, St. Louis Section; Davidson. Standing, from left: B. M. Coons, Chairman Speakers' Committee; Parke Underwood, Committee Member; A. G. Werner, Treasurer, charter member St. Louis Section; Stan Pueser, Chairman Ladies' Entertainment Committee; Eugene Brockland, Committee Member; Chris Kacalieff, Chairman Program Committee; Robert Klorer, Chairman Printing Committee; Jack Porte, Committee Member; Peter Spink, Chairman Prize Committee; Robert McDorman, Co-Chairman, Publicity Committee.

NEWS of the industry

On the Cover

Plastic Forming Press for Hard to Fabricate Items

Forms that are hard to fabricate due to shape or material thickness can now be processed easily with a new Forming Press called the STAR, which has just been announced by Comet Industries, 9865 Franklin Ave., Franklin Park, Illinois.

New forming techniques have been incorporated into this machine which include: snap back forming, pressure forming, mechanical forming, and vacuum forming and trimming in one operation. Unlimited applications and combinations of forming techniques are said to be possible.

Basic operations consist of the automatic withdrawal of a superheated plastic sheet from an enclosed oven. The heating of the plastic sheet evenly on two sides reduces cycle time to an absolute minimum.

This machine is equipped with counteracting platens which provide for plug assist or hold back directing control on the plastic sheet during forming operations. Each platen is capable of carrying a mold or helper and performs a complete fabricating operation.

Vacuum may be applied through either or both platens simultaneously depending upon forming technique desired. Even the simplest application can make use of the sag in the sheet.

On this press the sheet is securely clamped in a central position between the two platens. Each platen is electrically driven and individually controlled to and from the forming area.

Automatic cycling operations are pre-set in special timers. Loading and unloading operations may be by manual means, from extruder, or blanks automatically fed and automatically removed after forming.

Available in 4 standard sizes with mold areas 36" x 48" to 60" x 96". Special adaptations are available. Air pressure required 100 PSI, platen stroke—upper 27"—lower 34". Electric current—220 or 440 volt, 3 phase, 60 cycle.

For complete information write the manufacturer, Comet Industries, 9865 Franklin Avenue, Franklin Park, Illinois.

Horizontal Tube Mounts

These new right angle tube sockets mount tubes horizontally, thus reducing space requirements, especially significant in printed circuits. Manufactured by Aerovox Corporation of Monrovia, California, the new tube sockets are molded from Plaskon alkyd, resulting in excellent dielectric strength together with high resistance to heat and moisture.

PVC Pipe Price Down

Prices have been reduced by as much as 15% on all types of rigid unplasticized polyvinyl chloride pipe and fittings offered by the Alloy Tube Division, The Carpenter Steel Company, Union, N. J.

A New Release Agent

A new release agent that can be rubbed to an imperceptible film after application has been developed for easy parting of epoxy resin castings from plaster molds, or from metal, wood, or epoxy masters. In addition, the new agent, which seals surface pores to exclude even water vapors, is effective in parting plaster from plaster or gypsum cements. The product, economical compared with existing release agents, is available in pints, quarts, and gallons from Smooth-On Manufacturing Co., 572 Communipaw Avenue, Jersey City 4, N. J.

Foam-King Grows

It is with great pride that FOAM KING, INC. announces the removal and enlargement of their laboratory-plant facilities to a full grown factory set up at 1816 Boston Road, Bronx 60, New York, which has been created for the purpose of meeting the demands of our ever growing list of prospective customers and licensees.

Dickmont Plastics In New Molder

We announce the formation of a new Plastics Molding Plant in Stamford, Conn. The name of the company is the Dickmont Plastics Corp. and is located on the corner of Selleck St. and Harvard Ave. in Stamford. The owners are Richard Scalise, of Stamford and Armand Marcucilli, from Harrison, N.Y.

Mr. Scalise is president of the company and has had 20 years of experience in the plastics field, having worked 13 years for P.M. Industries as General Foreman in charge of injection, transfer, and compression molding. For the past 7 years he has been connected with Atlantic Plastics, Inc., located in Stamford, in the capacity of Production Manager.

He graduated from the Plastics Industrial Technical Institute in 1945 and completed two courses of study of vocational training through the Conn. State Department of Education.

Mr. Scalise served as president of the Industrial Management Club in Stamford and was on the executive committee of the Conn. State Council of Industrial Management Clubs. He has been an active member of the Conn. S.P.E. chapter since 1948.

Mr. Marcucilli is treasurer of the company and has had 15 years of experience in plastics. He worked for P.M. Industries for 6 years as foreman in charge of transfer, compression, and injection molding, was foreman at Progressive Plastics in the Bronx, N.Y. for 4 years and Plant Superintendent since 1952 for Merit Creations in Mamaronek, N.Y.

Mr. Marcucilli completed two courses of study of vocational training through the Conn. State Dept. of Education and is an active member of the N.Y. chapter of the S.P.E.

W. F. Christie Appointed

William F. Christie has been appointed Sales Representative of the Plastics Division for the Middle Atlantic States, it was announced today by Walter W. Peacock, Jr., Plastics Division Sales Manager of Escambia Chemical Corporation.

C. W. Brown—President

The appointment of Clifford W. Brown as President of Narmco Resins and Coatings Company, Costa Mesa, California, was announced today (September 27) by Dr. Glenn G. Havens, Chairman of the Board of the parent firm, Narmco, Inc.

Mr. Brown was formerly vice president and general manager of the Southern California firm, which manufactures a wide variety of structural adhesives, fiberglass laminating materials, and related products for aircraft and commercial industries.

High Pressure Ethylene

The introduction of the first commercial quantities of a new high density polyethylene molding resin produced in a high-pressure type plant was announced by Spencer Chemical Company, Kansas City, Mo. The new resins, with densities ranging from .935-.940, exhibit greater stiffness, much higher heat resistance, less permeability, and greater strength than standard or intermediate density polyethylene, while retaining the desirable non-toxic and odorless properties usually associated with polyethylenes from the high-pressure process. Spencer is the first U. S. polyethylene producer to offer resins with this high density in commercial quantities.

Kenneth A. Spencer, president of the Kansas City firm, said that an intensive developmental program by the company has made the introduction of these new resins possible, although Spencer has operated its 45 million pound per year Orange, Texas, Works for only 18 months. Spencer initially began polyethylene production under licenses from Imperial Chemical Industries, Ltd., but the new resins were developed independently of the British firm.

Hercules Perspex

A new $11 million Perspex plant is to be built in Louisiana, Missouri, in a joint Anglo-American project. The two big companies involved are Imperial Chemical Industries Ltd., whose process it is, and Hercules Power Co., who will operate the concern.

The plant will be built on a 20-acre site adjoining the Missouri Ammonia Works. It will have an annual capacity of 34 million lbs. of methyl methacrylate. Both monomer and polymer in various forms will be made and sold.

Methyl methacrylate is a chemical with many applications, although it is most commonly known today in polymeric form as polymethyl methacrylate. This is a glass-like plastic widely used in sheet form in aircraft, automobiles, and illuminated signs, and for many other purposes.

Plastic Molders' Supply

As a first step in a new expansion program, Plastic Molders Supply Co., Inc., of Fanwood, New Jersey, have completed arrangements for branch offices and production plant in Sandusky, Ohio.

The new plant, located on Columbus Avenue, will be managed by A. K. Van Cleef, who will also be in charge of sales. Frank Czech will be in charge of production.

According to W. B. Bradbury, President, the new plant will begin operations September 1st and will have the latest and most complete facilities for dry coloring all thermoplastics.

Men In The News

Edward S. Coe, Jr.

Edward S. Coe, Jr., vice-president of Farrel-Birmingham and recently elected to the board of directors, has been appointed general manager of the company's Consolidated Machine Tool Division, Rochester, New York.

He succeeds Lester D. Chirgwin, who formerly headed this division. Mr. Chirgwin recently requested a leave of absence which will extend until the date of his formal retirement at the end of the current year.

S. H. Williams

S. H. Williams, Vice President of General Aniline & Film Corporation, has been promoted from his present position of General Sales Manager to Assistant General Manager, Dyestuff and Chemical Division, effective September 1st.

Mr. Williams has been with General Aniline for 28 years joining the Company as a Technical Salesman. He rose to the position of Manager of the Company's Charlotte, N. C., branch in 1941 and in May 1952 was advanced to the position of General Sales Manager of the Dyestuff and Chemical Division. He was elected Vice President in 1954.

Leo E. Rinal

Announcement is made by Mr. J. B. Carroll, President of the J. B. Carroll Company of Chicago, manufacturers of Plastic Specialties and Displays, that Mr. Leo E. Rinal has joined the Display Division of the company as Special Representative. Mr. Rinal is well known to users of Point-of-Sale Displays thru-out the the mid-west and has had more than thirty years' experience in the origination, development and production of displays of national fame.

L. G. Boatright

Dr. Leslie G. Boatright has joined Escambia Bay Chemical Corporation, it was announced today by A. N. Wohlwend, Director of Commercial Development.

He is located at the company headquarters, 261 Madison Avenue, New York City, where he will devote his full time to the activities of the Commercial Development Department.

B-L-H Transfers

Baldwin - Lima - Hamilton Corporation announces the transfer of John J. Littley and Byron B. Belden from the Eddystone, Pa. Division to the Hamilton Division.

With the recent transfer of the Baldwin hydraulic and compacting presses to Hamilton, Ohio, Mr. Littley will serve as Sales Manager of hydraulic and compacting presses.

Mr. Belden will serve as application engineer for Baldwin compacting presses.

Pyramid Plastics Bought

Robert J. Huber, President, Michigan Chrome and Chemical Company, Detroit, Michigan, announces the acquisition by that company of the assets of Pyramid Plastics Company, of Chicago.

Michigan Chrome, a major manufacturer of vinyl plastisols and specialized industrial coatings, thus acquires the facilities of an established, specialized industrial extruder.

The facilities in Chicago will be expanded to manufacture and warehouse Miccro Products for better service to the Midwest area, according to Huber.

Pyramid Plastics will continue operations under the same name with James Palmer continuing as President and General Manager.

Huber also announces the formation of Michigan Chrome and Chemical Ontario, Ltd., for the manufacture and distribution of Miccro Products in Canada.

A. L. Donaldson

Appointment of Alexander L. Donaldson to technical service manager of the reinforced plastics division has been announced by Minnesota Mining & Manufacturing Co.

For the past year he has been assistant manager of product applications in the industrial trades tape laboratories. He joined 3M in 1951 as a quality control inspector and later was made technical service engineer. In 1953, he was promoted to technical service supervisor.

H. T. Cusic

U. S. Polymeric Chemicals, Inc., Stamford, Connecticut, manufacturers of impregnated fabrics, papers and mats for the plastic industry, has announced the appointment of Mr. Howard T. Cusic as Industrial Sales Manager.

Mr. Cusic, formerly Detroit sales representative for Owens Corning Fiberglass Corp., Toledo, Ohio, is a graduate of Princeton University where he majored in chemical engineering and was a varsity member of the football and track teams.

Automatic Molding

Automatic Molding Machine Company of Los Angeles, Calif., makers of Automold high-speed, fully automatic compression molding machines, announce the appointment of the following agents: Mr. Robert W. Brandt of Plastic Molders Engineering Co., Chicago, Illinois, to cover the territory consisting of part of Illinois, Wisconsin and Eastern Indiana; Mr. Don Boschert of Dunning & Boschert Press Co., Syracuse, New York, covering New York State, excepting Metropolitan New York City, and the states of Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island and Vermont.

THE INJECTION molderscope

A. R. Morse
Injection Molders' Supply Co.

France and Spain

After 2 months in France and Spain it finally dawned on me why the U.S.A. offers us such opportunities: We have a 165 million market. Any single European country is lucky to have a quarter of that. Because of boundaries and currency trade restrictions between countries, no company in Europe can grow by specialization. Most leading Americans injection molders are fast becoming specialized in some one field and there is a wide difference between the European pace and outlook and ours (Germany excepted). Two things struck me at once. Most thermoplastics that reach the consumer in France and Spain at least, are top quality. There seems to be no pirating, no copying, no cheapening. When you lift a piece of polyethylene in a store you know you have hold of a rugged piece of merchandise. I looked over a lot of thermoplastic articles, buckets, bedpans, bidets, bottles — all were of a uniform quality generally superior in design and cross section — and probably in utility to ours. There were no "cheap" plastic articles seen in the stores, and the customer often had to pay considerably more for a plastic item than a metal one. The store owners were universally proud of their thermoplastic goods. I never heard the word "plastic" slurred like you do in stores here where clerks have had bad experiences with thermoplastics.

The second thing that impressed me was the leisurely pace of molding operations. In many cases the cycles were slower than ours, and I believe that lower heats and longer cooling time accounted for most of the extra time with a noticeable improvement in product strength. In polyethylene in particular I could not account for the quality of the work being done until I finally learned the cycle and then it was immediately apparent how they kept decomposition and crazing to such a low level—with low heats and long cycles. You don't find operators in American plants with time to read a newspaper, or to sit down in a chair for a short smoke between shots!

There is always the danger of generalizing from too few examples, so I won't say any more here except to note that it is pretty hard for us to sell anything for dollars in Europe, and certainly not on a normal markup. The **extra** expenses of doing business abroad I have calculated at about 20%. For the average small business man and many large concerns too, I doubt the wisdom of trying to tap the continental market. Lets face it. With the Germans getting in high gear we will be OUT altogether, except as a source of know how that doesn't have to go through customs or have to bother with exchange! We are, however, well ahead in equipment, and in molding powder pricewise and quality wise, and I believe it can be said in tooling too. If the gap closes at least in France and Spain, it will be the German's who get the business, not the U.S.A.

Ideas Flow Upwards

Mr. Herbert P. Buetow, President of Minnesota Mining and Manufacturing Co., in an important address on what research has done for his company said, "We recognize also that good ideas do not necessarily stem from the top. We encourage the flow of ideas from the bottom upward. We don't think it is necessarily the duty of our technical directors to originate ideas . . . but we assign them responsibility for screening the ideas and for fighting with top management — (if a fight is necessary) — to get financial support for those ideas which survive the early screenings."

His remarks point up a real problem that the injection machinery people in particular, and also the large injection molding divisions of large companies have today; how to get ideas to flow upwards in a company. Minnesota has been eminently successful in this, and their healthy situation shows what happens when you reverse the usual flow of ideas, and use the executive staff to screen ideas on the way up rather than to originate often impractical ideas which are then supposed to filter down to the "field." All of us in the injection industry could do well to review our way of looking at things, because the biggest untapped area of resources in our industry is at the field service level. Whether you are in machinery, in materials, or in molding, the most important thing is to remember that the best ideas come right from the molding foreman and the press operator, not always from Mr. Bigdome, (who naturally likes to get the credit). By giving credit where credit is due, and letting ideas flow upward as Mr. Buetow advocates, the injection industry can do much to consolidate our scattered technical know how, to turn our art into a science. Many of the serious injection machine problems of 1956, and the shifting of leadership in the injection equipment field are due to the fact that in some concerns ideas are now flowing upwards and in others the old concept still prevails that the low man on the totem pole is just a stupid slave supposed to do only what he is told. Mr. Buetow continues: "We want to think in terms of people and ideas. We want our men to continue searching for ideas, to be stimulated by them and perhaps fight for them, if necessary. We want our scientific people to retain their curiosity when they come to work with us . . . and we hope the environment we have created will stimulate them to do their best. However, we realize that environment is not everything. We also count on several other catalysts — including the salesman who sends in his problems from the field, and the engineer who helps blueprint the answer."

S.P.I. To Meet In Los Angeles, 1957

Plans for the 1957 Annual National Conference of The Society of the Plastics Industry Inc. to be held in Los Angeles, California next year, will be formulated at a meeting scheduled by James Prior, Chairman of the SPI Pacific Coast Section on August 22 in that city. Also at that time plans will be advanced for the proposed Pacific Coast Plastics Exposition to be sponsored by the Society.

For some time the Pacific Coast Section has been anxious to act as host to SPI's annual conference. With the tremendous growth of the aircraft, construction, electronic, packaging and general industry in the area, West Coast plastics manufacturers have urged holding a representative plastics trade show in California.

The recent annual conferences of the Society have been departmentalized with separate sessions devoted to particular subjects such as aircraft, communications, packaging and transportation. Speakers from these industries have been scheduled to talk on plastics. They have dealt with particular applications, requirements, potentials and other pertinent subjects.

AROUND THE WORLD

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BRAZIL

REVISTA BRASILEIRA DE PLASTICOS

October, 1955

Abstracter: Louis A. Helwich

PLASTICS IN SPORTS

Applications of plastics in the sports field reviewed. High impact polystyrene fishing tackle, motorists protective helmets of urea, reinforced polyester crossbow, nylon tennis rackets, polyethylene golf and tennis balls, reinforced polyester boats etc.

SOME PHTHALATE PLASTICIZERS AND THEIR MIXTURES — Otto Pesta.

Comparison of properties of di-2-ethylhexyl phthalate, dialphynil phthalate and di- nonyl phthalate and their combinations as plasticizers for PVC.

CEMENTING OF PLASTICS — Eric Jeanrenaud.

Thermoplastics are discussed and cementing of articles of materials of the same type. Practical directions for cementing polystyrene, cellulose plastics, acrylics, polyamides and vinyls.

November, 1955

PVC ONE OF THE MAJOR INDUSTRIES IN JAPAN.

A situation report. The production of polyvinyl chloride in Japan has developed only after the second world war and attains at present 2000 tons monthly. This compares with 200 tons monthly in 1949. About 20 different companies have initiated the production since the war and the competition was very strong. At present some of the most important remaining producers are: Electro Chemical Industrial Ltd., Japanese Geon Co., Ltd., Kanegafuchi Chemical Industrial Co. Ltd., Mitsui Chemical Industry Co. Ltd., Monsanto-Kasey Chemical Co., Nippon Carbide Ind. Co., Shin Nippon Chisso Hiryo K. K. etc.

CEMENTING OF PLASTICS — Eric Jeanrenaud.

Adhesives based on synthetic resins and their application in cementing of rigid objects discussed. Attention is paid especially to phenolic and urea based adhesive compounds.

December, 1955

PLASTICS, ONE OF THE MOST DYNAMIC INDUSTRIES IN BRASIL.

A review with illustrations of plastics products now manufactured in Brazil.

INDUSTRIAL ACTIVITIES.

Present state of development of different companies producing plastics materials in statistical numbers. Imports of plastics materials compared.

Production of synthetic resins and some raw materials:

Polystyrene	6000	7440	9600
Polyesters	30	60	200
Phenolic resins and molding powders	2400	2740	3440
Urea resins and molding powders	2300	1580	3500
Vinyls	2400	2820	6360
Celulosics	600	500	800
Alkyd resins	1600	1900	3300
Maleic resins	700	750	1250
Acrylics	280	450	1000
Ester gums	120	260	440
Galalite	140	150	170
Nylon		100	200
Phthalic anhydride	350	700	1400
Dryers (resinates & naphthenates)	350	400	700
Plasticizers	300	600	1200
Vinyl chloride monomer		3600	7200

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GERMANY

KUNSTSTOFFE

June, 1956

Abstracter: Anne Schwend

PLASTICS AND PLASTICS PROCESSING AT THE GERMAN INDUSTRY FAIR, HANOVER 1956

First survey on exhibition of plastics and processing machinery shown at Hanover in April 1956.

CHEMICALS:

Farbwerke Hoechst: "Hostalen" Ziegler polyethylene as colorless and black granules of different molecular weight; extruded bubble-free rods and tubes from "Hostaflon" (polytrifluorochloroethylene); polyethylene glycol therephthalate fibre "Trevira" of the woolen type; manufacture of silken Trevira fibres will start shortly.

Kalle & Co.: "Suprathen" polyethylene films of 1800 mm width are gaining in importance for building and insulating purposes (covering of scaffoldings to protect building from rain and cold). Surface of film was improved so that it will retain printer's ink very well. Aluminum vacuum coated on "Hostaphan" film (polyethylene glycol therephthalate) is used for condensers in the electrical field. Recent additions to manufacturing programme: "Mowital" films as intermediary layers for safety compound glass; polyvinylalcohol film as mold release agent for molding polyesters.

Dynamit A.G.: polyester corrugated glass, molded continuously, profile corresponding to that of corrugated sheet metal.

Anorgana GmbH.: Novel fine film from plasticizer-free PVC, almost transparent, as tubes or flat sheeting. Also, PVC profiles for the wicker-work industry.

Roehm & Haas: Plexigum tubes, profiles and ribbons, extruded endlessly in considerable diameters and widths. Nice modern chairs with Plexiglass seats and backs.

Chemische Fabrik Dr. Raschig: "Fibresinol" molding compound filled with rayon fibres of 10 to 20 mm in length, particularly suitable for transfer molding. A powdery addition "Rapok 49" to buna or phenolic formaldehyde resins for the production of brake linings guaranteed to retain frictional values also at elevated temperatures.

H. Roemmler GmbH.: Hard paper coated with a copper film for printed circuits competing now with foreign material regarding quality (adhesive strength).

Rheinische Gummi—und Celluloidfabrik: Plasticizer-free rigid PVC films, stretched and unstretched, for packaging.

The progress made by plastic tubes and fittings of PVC and polyethylene

Kunststoffe *(Continued)*

as well as the advances of polytetrafluoroethylene, Teflon, into broad spheres of application in the German industry are investigated and examples cited.

INJECTION MOLDING MACHINES:

Ankerwerk Gebr. Goller: A novel small high-speed injection molding machine molding up to 75 grams of polyethylene in one shot, making 15 shots per minute at fully continuous operation.

Gebr. Battenfeld: have transferred their design principle of driving molding presses electro-mechanically also to injection molding machines; built-in hydro-pneumatic device for holding pressure after injection may be adjusted to pressure needed.

Maschinenfabrik P. Flesch: A special drive for the injection plunger has been abolished in a new, fully hydraulic horizontal injection molding machine. For injection, the injection cylinder is driven towards the stationary plunger which forms the feed plunger at the same time.

R. H. Windsor: showed their new type W 30 injection molding machine with a capacity of 300 grams per shot.

In Dr. Sommer's high-speed injection molding machine the plasticizing cylinder moves over the stationary plunger during the injection cycle.

Maschinenfabrik Albert Stuebbe: developed a feed weighing device guaranteeing accurate weighing regardless of kind and granulation of molding material.

Extruders, to a large extent, were exhibited complete with all sorts of take-up equipment for the production of manifold shapes.

Maschinenfabrik Reifenhaeuser developed an extruder with electrical machine switch station extendable on the operator's side. Detachable walls permit free access to the main motor.

Maschinenfabrik Wenigmann introduced a high-output extruder having four unsymmetrical screws coupled by ring gears and running in a profiled barrel. Screw length is about one quarter of that of a single screw extruder. The feed weighing device distributes molding compound evenly onto the four screws. This extruder is said to process non-gelatinized powdery raw materials. Drying of compound is rendered superfluous since moisture is being expelled backward before the material enters the compression zone.

The same company showed an interesting design of a blow extruder with two molds for continuous operation.

Alpine A. G. have taken up the production of extruders with high-speed screws, thus augmenting the output considerably. Mechanical energy is used for heating the compound, the screw forming the feeler for the required viscosity and controlling the power consumption, thus rendering superfluous any heater or cooler installation, all equipment for automatic temperature control as well as the gears judged indispensable up to date.

The first automatic **welding machine** with rotary work platen built in Germany was introduced by Alfred Schwalbach K. G.

Koerting Radio-Werke GmbH. have developed automatic conveyors and rotary tables as well as feeding apparatuses for the automation of production.

A new horizontal cutter for vacuum formed parts was introduced by Alfred Schwalbach KG.

In contrast to extruders, the continuous kneading screw of Werner & Pfleiderer works without pressure and evacuates the mixed compounds in fist-size lumps.

A completely new principle for dry-powder mixing and wetting of powdery or fine granulous plastics with pigments, stabilizers, plasticizers, lubricants, etc., is realized in the "Fluid-Mischer" of Henschel Flugmotorenbau GmbH. which makes use of the turbulent flow principle in combination with high-speed grinding and mixing tools.

THE INJECTION MOLDING MACHINE HEATING CYLINDER

Excerpt from the paper presented at the 11th Annual National Technical SPE Conference by C. E. Beyer, R. B. Dahl and R. B. McKee.

SPEED OF POLYMERIZATION OF COMPOUNDS OF UNSATURATED POLYESTERS WITH DIFFERENT CATALYZERS—Dr. P. Maltha and L. Damen.

Suggestions by the SPI for the gelling time of unsaturated polyesters prompted the authors to conduct tests and propose an equation for the relation between the speed of polymerization of unsaturated polyesters on one hand and the activity and concentration of catalyzers on the other hand. It does not seem as if test results would permit definite conclusions for the time being.

TEMPERATURE LIMITS FOR VARIOUS MATERIALS. Reprint in German from SPE Journal, October 1955, page 27.

NEW WAYS OF PRODUCING PVC PASTES—T. Hugosson

Based on Swiss patent No. 272.263 the influence of different fractions of granule sizes on the viscosity of PVC pastes is investigated and it results that a mixture of fine granules with granules six times as big yields very low-viscous pastes. Depending on the proportion of small to bigger granules, pastes of identical viscosity but of varying plasticizer content may be produced and products of predetermined hardness may be had from such pastes of identical viscosity. Pastes in which the proportion of fine fractions is higher than that of coarse fractions have proven to be better resistant against ageing. Sedimentation during storage only occurs when the content in coarse fractions is extremely high, f.i. 90% or higher.

EXTRUSION DIES FOR PIPES, TUBING AND PROFILES — G. Schenkel.

Subject is reviewed by reference to a number of foreign articles (H. O. Corbett in SPE Journal of June 1954, among others). Problem of orifice design shall be investigated thoroughly soon.

DESIGN OF INJECTION MOLDS — Hans Gastrow.

Description of molds for the ejection of thin-section and deep-drawn polyethylene parts by means of compressed air and molds for mechanical ejection of parts with additional ejection by compressed air.

Kunststoffe

August, 1946

IMPACT STRENGTH OF POLYSTYRENE — Hilding Hogberg

The intention to prove a relation between molecular weight and impact strength in different styrene materials could not be realized by the tests conducted since it appeared that impact strength values obtained are highly dependent upon conditions prevailing during production. Tests conducted are meant as a contribution to the endeavours of ISO TC 61 committee to come to internationally uniform test procedures so that different offices can get the same results.

Factors to be considered in impact strength tests of polystyrene are discussed: manner of production of test bars, Charpy pendulum and basis of calculations, impact tests on specimen, influence of diameter of sprue on the impact strength of bars, influence of plunger advance time and high cylinder temperatures as well as favorable effect of ball check nozzles, reproducibility of tests, adequacy of injection molded or compression molded specimen, influence of notching on impact strength results, inadequacy of the drop weight test, the same as anisotropy and ageing of samples.

QUANTITATIVE DETERMINATION OF UREA AND MELAMINE IN UREA - MELAMINE - FORMALDEHYDE CONDENSATES — G. Widmer

In search of a simple method applicable also in laboratories not equipped with the most modern physical and chemical instruments, Kappelmeier's suggestion in Paint, Oil and Chemical Review, 1948, was followed up to convert urea in pure urea-formaldehyde into dibenzyl-urea and

weigh it. When this method retrieved 90 to 99% of the urea, an ammonification of urea-melamine-formaldehyde condensates with benzylamine also showed crystallization of dibenzyl-urea. The surplus in base and condensates of base with formaldehyde as well as conversion products of melamine remain solvent and can be washed out with diluted hydrochloric acid. Thus, 85 to 95% of the urea may be regenerated and weighed depending on whether the formaldehyde products are cured or uncured and fillers have to be separated.

Ammonification of urea-melamines with acqueous ammonia resulted in solutions from which the re-formed melamine partially crystallized and, by precipitation with picric acid, melamine could be quantitatively determined in the form of melamine picrate. Here again, due to a certain decomposition of melamine, approximately 90% of the original content in melamine could be traced.

CAUSE AND SIGNIFICANCE OF BI-REFRINGENCE MARKS IN INJECTION MOLDED POLYSTYRENE PARTS — Dr. Wintergerst and K. Heckel.

Bi-refringence marks appearing in injection molded polystyrene parts when viewing them in crossed polarizers, have mostly been considered as frozen internal stresses. Thorough investigations, however, showed that it is mostly an orientation of thread-like molecules which are forced into the direction of flow primarily through the friction offered by mold walls and the shear strain flow caused thereby. Orientation increases at the ratio as the wall diameter of the molded part decreases because of the increase in shear strain flow, which in turn entails a rising of optical anisotropy and, hence, bi-refringence effects.

MAGNETIC NUCLEAR AND ELECTRON RESONANCE — W. Bruegel

An introduction to magnetic nuclear resonance is followed by a survey on the present status of nuclear resonance spectroscopy with description of test apparatuses as built by Varian Assn., Palo Alto, Calif., and their application in the investigation of the crystalline and amorphous shares in high molecular materials, for determining certain processes during transitional configurations and in special thawing processes. The use of paramagnetic electron resonance for investigating irradiated plastics is briefed. U.S. literature is cited.

DESIGN OF INJECTION MOLDS — Hans Gastrow.

Description of a hot runnerless 3-cavity mold for tumblers.

HORIZONTAL CUTTER FOR VACUUM MOLDED PARTS — W. Hillesheimer

Several problems present itself to the designer of a horizontal cutter for vacuum molded parts: adaptation of the working cycle to that of the molding machine, universality as to cutting films of .2 mm and polystyrene plates of 5 mm in thickness, elimination of all oscillations during cutting so as to prevent brittling of parts. All of these problems have best been solved in a horizontal cutter working with a feed of 1 cm. sec. on polystyrene of 2 mm in thickness and abt. .5 cm sec. on rigid PVC of .2 mm in thickness, which is very delicate to cut, having a variable distance between feeding table (on ball bearings) and cutting plane of 3 to 15 mm as well as a quick action tentering frame adjustable to every thickness of material up to 5 mm, guaranteeing absolutely level tentering of the material. Track wheels suspended above the cutter band and adjustable by dead weight rolls or telescopic springs keep the material entirely plane in front and to the rear of the cutting area. Upon designing of molds the loss in height of parts by horizontal cutting has to be taken into consideration.

ELECTRIC EQUIPMENT FOR LAYING PVC BANISTER HAND-RAIL PROFILES

Description of a novel apparatus working on the principle of an infrared heating chamber for pre-heating of PVC profiles, temperature variable between 150 and 300° C. Further, welding irons based on the experiences with electric soldering irons have been developed with heater blades absolutely repellent against acid fumes developing during welding of PVC.

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GREAT BRITAIN

PLASTICS

June, 1956

Abstracter: Alfred T. Rexer

SECOND THOUGHTS ON GLASS FIBRE/POLYESTER PRODUCTS

A sort of editorial resume of the chequered life of the glass fibre polyester industry. The impregnation process and the pressure process are discussed with particular attention being paid to present complexities that require highly technical techniques for good work. Advances in the field are covered.

RADIATION IN THE PLASTICS INDUSTRY — R. Roberts

With the increase of radioactive sources, much work is being done to determine the effect of radiation on polymerized materials. In general the properties are not improved. One exception is polyethylene which undergoes cross-linking on irradiation.

P.V.C. PASTES — THEORY AND PRACTICE — M. S. Welling

A comprehensive two-part article gives a complete picture of p.v.c. pastes-plastisols and organosols. It covers the manufacture together with the theoretical and practical considerations of paste formulation.

HIGH MOLECULAR-WEIGHT NYLON — W. Stiner.

The author discusses the Grilon nylon materials with special reference to extrusion and the manufacture of foils.

THE PROPERTIES AND TESTING OF PLASTICS MATERIALS—Part 4, A. E. Lever

This section of the article covers color, haze, refraction, surface irregularities, glossiness, bleeding of color, and light.

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RUBBER AND PLASTICS AGE

Vol. 37, No. 8, Aug., 1956

Abstracter: Watson C. Warriner

TUBE INVESTMENTS RESEARCH LABORATORIES, HINXTON HALL, CAMBRIDGE

A discussion of theoretical strength of materials related to plastic reinforcing agents by an analysis of molecular and crystalline structure. Mica, ionic crystals, organic crystals, metal whiskers and glass are analyzed. The article deplores the lack of exploration into this fundamental field and suggests that intensive research would accelerate the development of stronger and stiffer materials of low density.

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MEXICO

RUBBER & PLASTICS

Aug., 1956

Abstracter: John B. Ballard

THE MANUFACTURE OF SYNTHETIC FIBRES IS SUFFICIENT FOR ONE DOMESTIC MARKET

The Mexican chemical industry is one of the ten most important industries in the country. Production of almost all types of chemicals increased in 1955. Production of cellulosic synthetic fibres now covers almost the entire domestic demand and there were no imports in 1955. Celorey, S. A., is a new company in this field, but most production comes from Celanese Mexicana S. A. plants in Ocotlan, Jal.; Zacapu, Mich.; and Rio Bravo, Tamps. Acetate and rayon fibre production increased over 20% and production of tire cord was started.

SPEAKING OF EXTRUSION

Edited by R. D. Sackett
Technical Service Associate
Monsanto Chemical Company
Springfield, Massachusetts

Fundamental Mechanisms In Polyethylene Extrusion—Part II

B. H. Maddock
Development Laboratories
Bakelite Co.

PART II

Part I included a review of extruder flow equations and a discussion on the effects of the die on extruder operating characteristics. Die characteristic lines and equations for determining die constants for 3 different shapes were given. The close relationship between the screw characteristic line and the die characteristic line was pointed out.

We are now in a position to evaluate some of the effects of the remaining extruder operating variables. Changing the cylinder temperature to produce a change in resin temperature may not have a significant effect on the output rate since it results in compensating effects in the screw and die. This is illustrated in Figure 10 for BAKELITE resin DYNH extruded through Die B at two temperatures.

Similarly, and for the same reasons, a change in resin viscosity or molecular weight has little effect on the output rate. This is shown in Figure 11 for BAKELITE DYNH (2.0 melt index) and DYNK (0.3 melt index) resins extruded through the same die (B) under the same operating conditions.

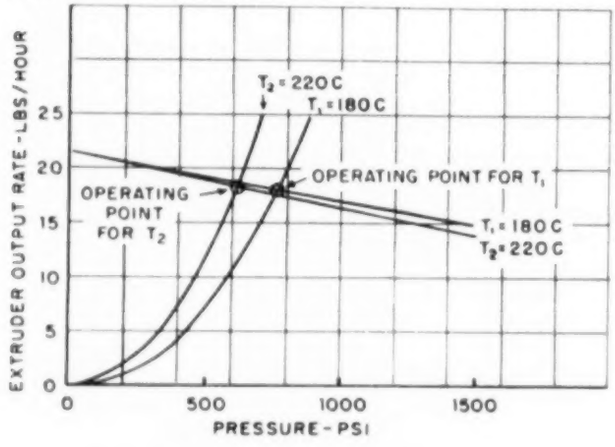
It can be shown that the amount of frictional heat developed by the screw and therefore the resin temperature, depends upon the screw channel depth, the operating pressure and the resin viscosity. The effects of channel depth and pressure have previously been indicated. (Figure 4). The effect of pressure is further illustrated in Figure 12 where DYNH resin temperature is plotted against screw for dies B (medium resistance) and C (high resistance). The pressures developed with die C are seen to have resulted in higher resin temperatures. The decrease in resin temperature with die B at screw speeds over 40 RPM indicates that the capacity for heat transfer from the barrel has been exceeded and that the screw does not develop enough frictional heat at the relatively low pressure level obtained with this die to prevent the temperature from dropping. This is a frequent cause of quality degradation in heavy extruded sections (low resistance dies) with increasing screw speed and output rate.

The effect of resin viscosity is shown in Figure 13 where the higher molecular resin, DYNK, extrudes from die B at a higher temperature than DYNH resin as a result of increased frictional working.

It can also be shown that the resin temperature developed at a given screw speed is directly related to the amount of mechanical energy input to the material from the drive motor. Figure 14 is a plot of resin temperature versus pressure for the four 2.0" screws previously discussed, extruding DYNH resin through die A at a screw speed of 48 RPM, cylinder temperature of 190 C and screw temperature of 100 C. Mechanical work, horsepower-hours per pound extruded, is plotted for the same system in Figure 15. When the resin temperature is plotted against mechanical work for all four screws, Figure 16, a smooth curve is obtained indicating that the temperature reached depends primarily on the amount of mechanical work, irrespective of the screw design.

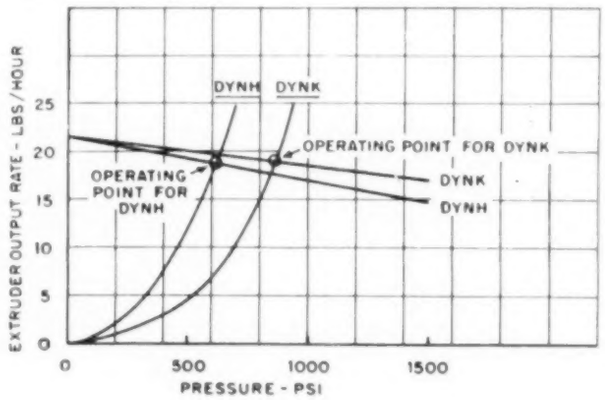
The amount of heat introduced by conduction from the cylinder wall, when added to that generated by mechanical action, determines the actual temperature level. Thus, lowering the cylinder temperature lowers the

Figure 10



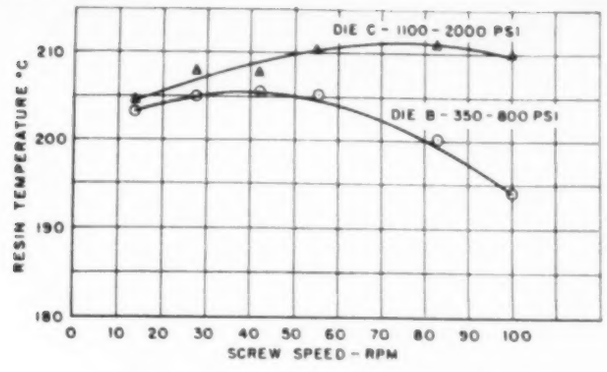
EFFECT OF RESIN TEMPERATURE ON EXTRUDER OUTPUT

Figure 11



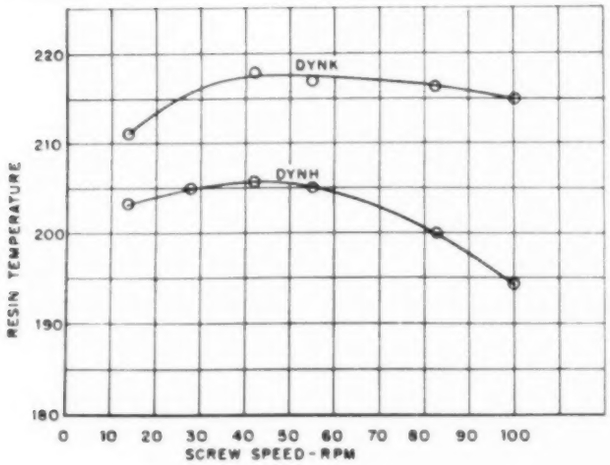
EFFECT OF RESIN VISCOSITY ON EXTRUDER OUTPUT

Figure 12



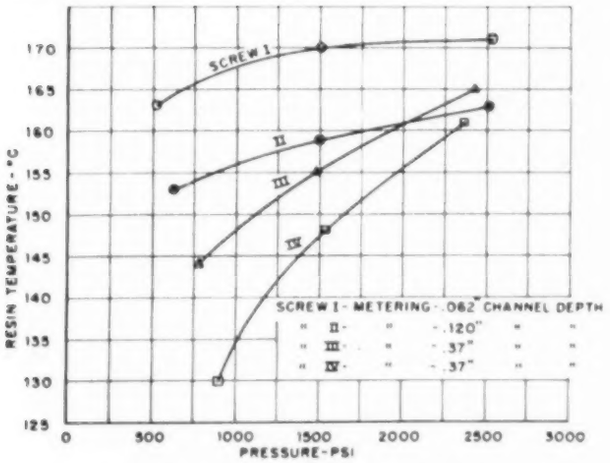
EFFECT OF DIE RESISTANCE ON RESIN TEMPERATURE

Figure 13



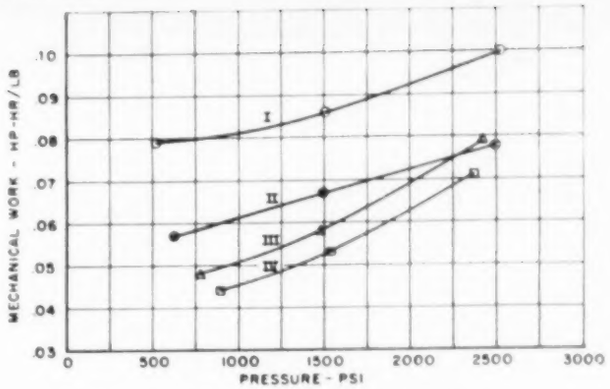
EFFECT OF RESIN VISCOSITY ON RESIN TEMPERATURE

Figure 14



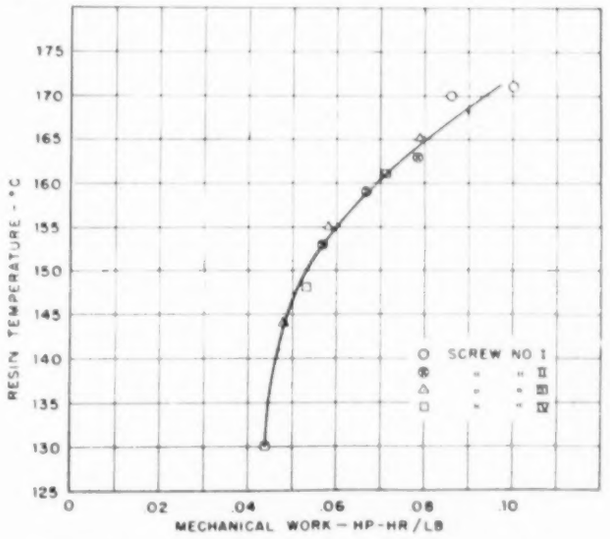
EFFECT OF PRESSURE ON RESIN TEMPERATURE

Figure 15



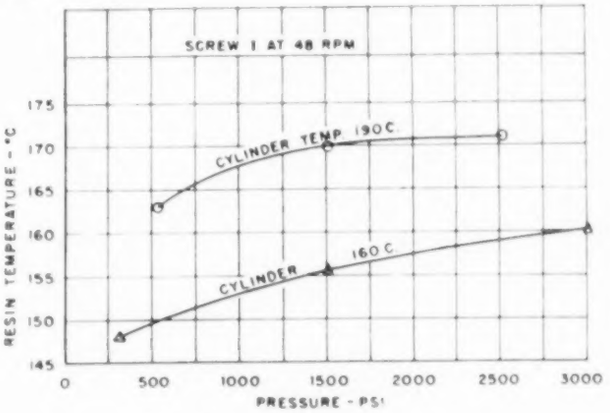
EFFECT OF PRESSURE ON MECHANICAL WORK

Figure 16



EFFECT OF MECHANICAL WORK ON RESIN TEMPERATURE

Figure 17



EFFECT OF CYLINDER TEMP. ON RESIN TEMP.

final resin temperature, but increases the mechanical work because of the higher average viscosity in the screw channel. This is illustrated for screw I in Figure 17.

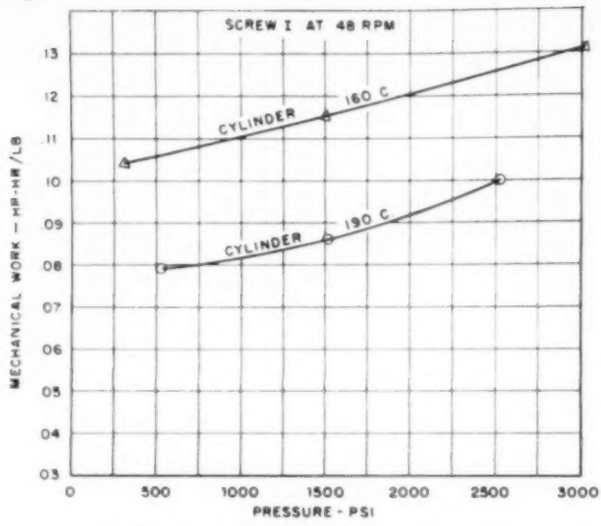
It is noted in Figure 17 that an increase of 30 degrees in cylinder temperature resulted in a rise of 12 to 15 degrees in resin temperature. A smaller rise would be expected at higher rates of throughput or in larger extruders where conditions for heat transfer from the cylinder wall are less favorable and a greater proportion of the heat input to the material is developed by mechanical action.

Relationships between mechanical work and the mixing efficiency of the screw now become apparent. By extruding tumbled mixtures of natural and colored polyethylene, a visual indication of the degree of mixing or dispersion is readily obtained. In the experiments illustrated by the data of Figures 14, 15 and 16, good dispersion was obtained only at mechanical energy input levels above 0.07 HP-hr./lb., regardless of the screw used. Thus while screw I gave good quality at all conditions, satisfactory quality was obtained with screws III and IV only at relatively high pressures (2000-2500 psi). Lowering of the operating temperatures would have resulted in increased mechanical work and improved mixing as previously indicated.

Cooling of the screw removes heat from the system and keeps the resin temperature at a lower level. The amount of mechanical work and the mixing efficiency are thereby increased, but the output rate is reduced by as much as 30 to 50 per cent. If latitude in screw speed range and drive power are available, the rate can be brought back to the original value by raising the screw speed, with a corresponding increase in power consumption.

In general, the mixing efficiency of an extruder screw and certain extrusion quality factors related to mixing and frictional heat development, are a direct function of the amount of mechanical work accomplished by the screw. The mechanical work can be increased by raising the operating pressure or by removal of frictional heat from the system, both of which cause a reduction in output rate for a given screw speed. Where screw speed or available power are limiting factors, quality improvement is generally accomplished only at the expense of production capacity.

Figure 18



EFFECT OF CYLINDER TEMP. ON MECHANICAL WORK

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frankly SPE aking

Our SPE Constitution says, in Article I, Section 2: The objects of the Society shall be to promote in all lawful ways, the Arts, Sciences and Engineering Practices and Standards connected with the utilization of plastics." The SPE Journal's technical articles contribute to the promotion of the latter three items. How, then, do we promote the Arts?

Perhaps the reason for this column's appearance in the Journal is not evident from the first few which you have read. The motivating thought is to promote the Arts by pointing out the advantages of utilizing this branch of Engineering to effect a greater acceptance of our skill and industry. Specifically, the Arts in Plastics can be defined as the systematic application of knowledge or skill in creating a DESIRED result.

I want to dwell on one particular aspect of this application of skill. LETTER WRITING IS A SKILL! It contributes much to our success as individuals. A business enterprise is judged by the **quality** of its communications. The reader is impressed or depressed according to the **skill** of the writer. Inept writing, carelessness in phrasing, and impersonal letters hamper the effectiveness of any sales or services letters.

The day of careful preparation, prudent review, and a protective sealing with wax and ring, has largely passed from the scene. This does not mean, however, that the letter cannot be couched in carefully chosen words to convey a precise meaning in facts or emotion. A carefully written message carries the man's personality so that the reader sees the writer there, alive, between the lines. Candor, humor, tact, pleasant news, sorrow, or censure can all be conveyed in their own way. A letter, without the man along, becomes a vague mediocre missive in the dull idioms of a parrot.

Let us consider some of the techniques of the orderly business letter-writer. He is careful of names and initials and signs a LEGIBLE signature over a typewritten name and title. A rubber-stamped or scribbled signature is a discourtesy to the receiver. Your secretary can take care of all the mechanical requirements of letter make-up. Only YOU can pass the real test of correspondence—the plain words, chosen with care and assembled into simple sentences. Pompous and officious terminology should be left to the dip'omats who love to use that type of language. Technical and abstract terms should be left to the writers of technical papers such as appear in other sections of the Journal (insofar as possible).

The Editors of Dun's Review and Modern Industry pointed the finger at a sore spot when they said: "Misunderstanding begins with the writer before it affects the reader, and occasionally the sesquipedalian word, or the Pentagon prose confuses when

(Please turn to page 64)

SECTION NEWS

Edited by
Charles P. O'Donnell
Monsanto Chemical Co.
Springfield, Massachusetts

St. Louis

SPE Membership of 50,000 Foreseen In Next 10 Years

Dan Otto

Envisioning an extremely bright future for the Society of Plastics Engineers, President Jerome L. Formo spoke to a dinner meeting of the St. Louis Section, SPE, in September.

President Formo has been visiting various sections throughout the country telling members of the history and of the great future plans of the Society. He was in St. Louis to meet with the National Council, SPE, at the Sheraton-Jefferson Hotel where the 15th Anniversary 1957 Conference will be held on January 16, 17 and 18. The Conference has as its theme: "Fifteen Years of Plastics Progress."

Two charter members of the St. Louis Section, Al Werner and Todd Clark, were in attendance as well as most members of the 1957 Conference Committee. Also on hand was C. H. Whitlock of Detroit, 1958 Conference Chairman.

Giving a preview of what he might expect to report at the 1957 Conference, President Formo looked ahead ten years and visualized a membership "not of 5,000 but 50,000." He predicted not just one journal, but "a set of magazines which will suit various phases of the industry."

"The Society will be broken up into divisions," he predicted. "Already, we have three this year. The experiences in the National Office will be beyond the fondest dreams. We will have 75 to 120 employes, meeting room facilities, printing presses, a research lab, a plastic institute and a college.

"All in all, there is a tremendous future for our Society with service to industry and the nation. The members are a great help. They make the dreams a reality."

Delving into the history of the Society, President Formo recalled that the Society was organized in December of 1941 in Detroit with the first incorporation in January of 1942. At that time, Chicago had a large section. By February of 1954, the sixth section was organized in St. Louis.

"Many things have happened since those days," he commented. "From nine formulating members in Detroit, we went to sixty members there to 5,000 members across the nation in just 15 years. We went from the small SPE News to the beautiful Society of Plastics Engineers Journal which, at first, was only a one or two page news bulletin.

"The organization has grown from a budget of zero to one of $185,000. Conferences have grown from those having 12 to 15 papers and 400 persons to 70 papers and 2,200 persons in attendance.

"The National Office, which was carried in one man's pocket, has enlarged to 10 people in two offices in the east and midwest. William Hoey served as first executive secretary for one year, then Bess Day held the office capably for five years when we had just 2,200 members. Then Jim Underwood took the post and now Jim Davidson is Executive Secretary.

"We are embarking on a bright, important future. We had to be humble at times. There was blood, sweat and tears in the early years to keep the SPE limping along.

"By 1956, we had outgrown our suit and had to tailor a new one. The first six months of this year we held meetings all over the country. We owe the Executive Committee a debt of gratitude.

"In June of 1956, a new blueprint was presented to the National Committee and it fit extremely well. The body is continuing to grow. The organization in the next two years will fit the coat extremely well," President Formo said.

Eastern New England

Plastics in Electronics Symposium for 1957

Alfred I. Simon

A joint meeting of the Eastern New England Section of S.P.E. and the Providence Chapter of S.P.I. was held on September 27, 1956 at the Hampton Court Hotel in Brookline, Massachusetts. Approximately 120 members and guests were in attendance.

President Ralph L. Mondano opened the meeting by announcing that a regional technical symposium on "Plastics for Electronics" will be sponsored by the New England Sections of S.P.E. in 1957.

It was also stated that despite membership losses to the relatively newly-formed Pioneer Section, local membership is increasing. It was also announced that the National S.P.E. membership drive is now underway. Mr. James Davidson, National S.P.E. Secretary, was then introduced by President Mondano. He made some encouraging comments on the future of S.P.E.

Dr. Richard B. Greene of the Barrett Division of Allied Chemical and Dye Company was introduced by Program Chairman, Gim P. Fong. His subject was "Polyurethanes—The New Old Resins." Dr. Greene presented a partial history of the original work on polyurethanes both in Germany and the United States. He pointed out that the aliphatic diisocyanates were dangerous to work with, thus delaying the use of polyurethanes for a number of years. Aromatic diisocyanates, on the other hand, which are not as difficult nor dangerous to work with, but which require careful handling, led to the further development and usage of polyurethanes.

Foamed-in-place applications offer a large market for polyurethanes. One such application is their use in boats, where the rigid and semi-rigid polyurethane foams make them unsinkable and stronger. Another application lies in trailers where the use of polyurethane foams offer high structural strength and good economy due to the low densities that can be obtained (as low as 1.2 pounds per cubic feet.) A third application is in polyurethane foamed mattresses which have become popular in Europe but have not as yet been accepted in the United States. By the end of this year, it is expected that the rate of polyurethane foams will be one hundred million pounds per year.

Polyurethanes made by combining linear polyesters and isocyanates can produce adhesives which will adhere to practically all plastics except cello-

phane, Mylar and polyethylene. These adhesives have a high reactivity with hydrogen, even that amount found in a moisture film.

While polyurethane coatings have shown superior properties, they have the disadvantage of having to be mixed and immediately used. Also, while the quality is high, the cost is also high, running about one dollar per pound as opposed to two dollars per gallon for industrial paint. Polyurethane varnishes using phenol as the solvent have produced industrial finishes with a tenacious bond. This application has been limited, however, due to the corrosive nature of phenol.

While there have been some applications for both thermoplastic and thermosetting polyurethane molding resins, the apparent high impact reistance is more than offset by the over all more desirable properties and lower prices of nylon at the present time.

Mr. William G. McLain of B. F. Goodrich Company, then presented a talk on "Cellular Vinyls." He stated that new materials must be advantageous in cost, properties and ease of operation by comparison with existing materials. Out of a total of two hundred million pounds of foams used in 1955, four and one half million pounds were of the vinyl variety. He predicted that by 1960, out of a total of six hundred million pounds of foams used, three hundred million pounds will be rubber foams, while the remaining three hundred million pounds would be equally divided between vinyl and polyurethane foams.

Plastics are foamed chemically by gas forming blowing agents or mechanically by incorporating an inert gas. Among the chemical blowing agents mentioned were BL 353, Unicel ND, Celogen O.T., and Celogen AZ., all of which release nitrogen gas on being heated beyond their decomposition point. Vinyl foams may be rigid or flexible, have open or closed uniform cell structure in a wide range of densities. It is important that a vinyl foam compound be so formulated as to control the gel point of the plastisol with reference to the decomposition point of the blowing agent. This is done by the proper selection and ratio of plasticizers. Some of the advantages of closed cell vinyl foams are:—relatively low cost, light weight, flame resistant, corrosion resistant, good heat and sound insulation, high tensile and tear strength, wide resiliency range and good buoyancy. Chemically blown vinyl foams can be manufactured in a continuous process where the foam is gelled at one temperature and fused at another. The height or thickness limit at the present time is three inches using conventional heating and six inches using R. F. heating in the fusion stage only.

Mechanically expanded vinyl foam can be made by dissolving inert gas into the vinyl plastisol at low temperatures (30°F. to 40°F.) Mixing and spraying or discharging of the mixture onto a belt or mold give volume production of open cell vinyl foam. Since open cell and closed cell vinyl plastisol formulations are similar, their physical properties are comparable. One exception, however, is moisture and water absorption. Open cell vinyl foams are used as sponges.

A question and answer period followed each of the talks.

R. I. & S. E. Mass.

Plan Conference

Glenn A. Tanner

The first meeting of the fall, and the kickoff meeting for the season's program for the Rhode Island and Southeastern Massachusetts Section, was held Thursday, September 27th at Wayland Manor Hotel, Providence, Rhode Island. The meeting had an excellent attendance, 40 members, to view Monsanto's new color film "The World That Nature Forgot," and to hear Mr. Robert McCarthy of Monsanto Chemical Co. talk on the current status of styrene plastics.

The new officers for this year will administer the section until spring. They are: Mr. Edward I. Rose, Plastic Engineering Co., Pawtucket, R. I.—President; Mr. Sydney Lohman, Lester Phoenix Corp., Providence, R. I.—Vice President; Mr. Howard J. Amster, Reliance Molded Plastics, Inc., Woonsocket, R. I.—Treasurer; Mrs. Charles Chrones, Hassenfeld Bros., Inc., Central Falls, R. I.—Secretary.

The forthcoming New England sponsored SPE Technical Conference was announced by our section delegate, Mr. Glenn A. Tanner of Ralph B. Symons Associates, Inc. This is the first of a proposed annual series of New England Technical Conferences to be held by the SPE and will take place early in 1957 at M.I.T. University. The conference this year will be on the use of plastics in the electronics industry. From the tentative list of speakers, it looks like the conference should be a great success. Plans for these annual affairs call for the various New England sections to rotate in planning the conference and handling the majority of the arrangements. Arrangements this year are being handled by the Eastern New England section.

After the business meeting, Mr. Robert McCarthy of Monsanto Chemical Co., Springfield, Massachusetts, with the assistance of Mr. Robert Johnson, local Monsanto representative and member of our section, presented the new 16 mm. color film "The World That Nature Forgot". This is a film of 30 minutes duration which tells the story of plastics in the layman's language. The purpose of the film is to create a greater interest and appreciation in the role which plastics play in everyday life. The film is of interest to both the layman and the technically trained plastics engineer. The color and the context of the film were excellent and I'm sure that all members enjoyed it greatly. After the film, Mr. McCarthy presented an excellent talk on the present position of styrene plastics in our industry today. He showed how this material is now becoming strong competition for articles previously made of wood, paper or glass.

In the early days of plastic research, a material was developed and many years were spent in research to develop uses for this material. Today, however, we find that with the increased knowledge in techniques in polymerization and formulation of plastics that the procedure is somewhat different. The trained technician will start with the end product or end use and develop a material specifically for that end use.

This is possible since there have been great advances made in the chemistries of the high polymers and the chemist can actually plan ahead in his development.

By this method, various styrene polymers have been formed to give higher heat resistance, to make available improved high impact materials, to give solvent resistance, to give low-temperature resistance, and to offer scratch resistance. Presently under consideration are polymers which will have improved ultraviolet light resistance and weather resistance. Somewhat in the future are polymers which will repel dust from the surface and polymers which will be a clear impact material.

Mr. McCarthy was very definite in pointing out that some of these special materials are more expensive than standard. He likened it to the extra cost which customers must pay for stainless steels in order to obtain their properties. There is a need for stainless steel, and there is a need for the various types of styrene.

The same techniques are used in the development programs of other plastics as well. Mr. McCarthy closed by saying that through the cooperation of the plastics industry the research technicians can find out what is wanted and needed by the industry. They can then find the right materials by intensive research to solve these problems.

A very nice display was arranged adjacent to the dining room by Mr. Charles Chrones, our Secretary. Products were toys and novelties produced by the Plastic Department of Hassenfeld Bros., Inc., Central Falls, Rhode Island. All of the merchandise on display was drawn later as door prizes.

Newark

Naval Ordnance and Cost Estimating at First Fall Meeting

By R. Bostwick

The Newark Section opened its fall program with almost one hundred members and guests at its first meeting on September 12. John Lombardi gave the annual Treasurer's Report. Pete Simmons introduced our National President, Jerry Formo, who gave a short talk. Don Biklen expressed the Section's thanks to our retiring program chairman, Norm Bragar, and turned the meeting over to the new program chairman, Al Spaak.

The first speaker was Dr. Albert Lightbody, Chief, Chemistry Division, U. S. Naval Ordnance Laboratory. Dr. Lightbody refuted comments that work done in government laboratories was not as good as that done in private laboratories. He said that the Naval Ordnance Laboratory decides, when a job comes in, whether it should be done there or contracted for outside. He pointed out that some jobs are not contractable, often for security reasons, and in some cases there is special competence at the Naval Ordnance Laboratory. Dr. Lightbody showed pictures of the laboratory and then discussed the functions of the Naval Ordnance Laboratory relating to plastics as he saw them. He included such items as trying new materials, establishing specifications, studying fabrication techniques, acting as consultant for other government groups and acting as a connecting link between engineering needs on the one hand and new developments in the plastic industry on the other hand. In connection with specification work, he mentioned corrosiveness of plastics as an area in which the laboratory was very active.

The second speaker was Mr. William Nussbaum, a certified public accountant specializing in plastics accounting. Mr. Nussbaum related some of his experiences in his practice and as a member of the SPI Executive Finance and Accounting Committee. He told of the activities of this committee, formed in 1943, to get uniformity in cost estimating of molded parts and continued stories in the industry of great variations in quotations on the same part. To check current conditions, Mr. Nussbaum took prints of parts which had been successfully molded in the past and had factory costs computed by estimators in several molding shops. The differences in final costs and in figures used during the calculations astounded Mr. Nussbaum. For example, calculated piece weight varied from 1336 to 1518 grams. Estimated reject rate varied from 2 to 20% and estimated cycle time varied from 36 to 75 seconds for the same make and model of molding machine. Mr. Nussbaum felt that such results pointed up the need for greater uniformity in accounting and estimating procedures.

Door prizes were donated by Boonton Molding, Newark Die and Prodex Co.

Among the changes during the summer was that of your correspondent, who has rejoined the Bakelite Co.

Kansas City

Rigid Polyethylenes

John E. Ferguson

The Kansas City section held its monthly meeting on Tuesday evening, September 4, 1956. This meeting, our first of the new fiscal year, was most successful. Mr. Ray Uber, District Sales Manager for Plastics Division of Phillips Chemical Company, was our guest speaker and discussed the rigid polyethylenes and their future in our industry. Mr. Uber brought with him a very interesting group of slide pictures showing various graphs and engineering information to compare the polyethylene materials that now are available. There was a larger response from the membership in questions for Mr. Uber and everyone seemed very pleased with the information that was obtained.

Prior to the meeting our Board of Directors met and among other things the program committee, composed of Mr. George Roach of Holiday Plastics and Mr. Robert Thomson of DuPont, outlined their program for the months ahead. It was unanimously agreed that the program as set forth would certainly be one of the finest yet established for our section and that we should have great success in answering the requests for information from our members.

Southern Cal

Cycolac and Penton

John Stahmann

The September 6 technical program of the Southern California Section of the S.P.E. was held at Scully's Restaurant . . . Two new thermoplastics, "Cycolac" and "Penton" were discussed.

Jack G. Fuller, Jr., of the Hercules Powder Company, introduced Penton, a chlorinated polyether, which is now available in semi-commercial quantities. Penton is not cross-linked, so it is completely thermoplastic. It is unusual in that it sets by crystallization into a strain-free solid. While a high percentage of chlorine makes it self-extinguishing, there are no beta hydrogens available, so there is no mold corrosion problem.

The dimensional stability of Penton is exceptional, having a water absorption of 0.01%. The heat distortion point is 300°F. It has good abrasion resistance. These physical properties make possible the production of gear trains, water pump parts, and timing mechanisms.

The general chemical resistance approaches that of polyvinyl chloride and fluor-carbons, although Penton is soluble in hot chlorinated solvents and fuming nitric acid. Use in refrigerator piping is suggested. Electrical properties of Penton indicate its use as an insulating material. It is remarkably stable under adverse conditions.

Penton is easy to mold or extrude. Its low melt viscosity gives good detail. Because of crystallization, mold control of temperature is necessary. Most shrinkage takes place before setting. Since Penton is still rather expensive, the products designed for its use will be those which take advantage of its distinctive properties.

Howard H. Irvin, the Technical Director of the Marbon Chemical Division of Borg-Warner, addressed the group on Cycolac. A copolymer of acrylonitrile, butadiene, and styrene, Cycolac is a high-impact rigid thermoplastic. It was described as being designed to fulfill as closely as possible a list of properties most desired in a molding resin.

Cycolac has a specific gravity of 1.01. This helps to give a good strength-to-weight ratio. Hardness is less than nylon. While it has a high impact strength, particularly at low temperatures, the range is less than that of polyvinyl chloride. Stress is proportional to strain up to 2 to 3 percent elongation. Creep of about 3 percent was found after three years at 1500 p.s.i. It has a high heat distortion point of approximately 300°F.

Tensile strength remains constant during a period of three months, while elongation and impact strength decrease. During a period of 12 months underground, no deterioration of properties was evident.

Good mold release is obtained with one-half percent of an internal lubricant. Low temperature and high pressures are used. Flow in a cylinder is highest at about 450°F; a temperature of 475°F is considered the maximum. Shrinkage perpendicular to the flow is half that parallel to the direction of flow. The best purging resin is an acrylic.

Regional Symposium

California Conference Scheduled For Nov. 16

Robert Steinman

The Symposium on Epoxy Resins will be held by the Southern California Section of SPE on November 16 and at 8:30 A.M. at the Institute of Aeronautical Sciences, 7660 West Beverly Boulevard, Los Angeles. The program was organized by the following committee:

Robert Steinman, Garan Chemical Corp., Chairman; William Dewar, Furane Plastics; Lou Constanza, Douglas Aircraft, Torrance; John Stahmann, Gladding, McBean; Paul Erskine, Hess-Goldsmith & Company.

A solid program has been evolved which will be strong on the technical aspects and the problems involved in the use of epoxy resins. The subjects to be covered and the men giving the papers, with a brief summary of each paper, is as follows:

"Three Epoxy Resin Systems for Elevated Temperature Use and the Effects of Cure Cycles on the Properties" will be presented by Mr. R. M. Maybee of Shell Chemical Corporation. The paper is confined to a general discussion of unfilled epoxy resin-curing agent systems at elevated temperatures and the comparative effects of a step-wise cure cycle on these systems. The systems discussed are (a) A liquid complex of aromatic diamines, (b) A boron trifluoride amine complex, (c) A diamino-aromatic sulfone with the boron complex.

Mr. Keith Cranker of the Thiokol Chemical Corporation will discuss "The Chemistry of Modifiers for Epoxy Resins and Their Effect on Properties." This paper will discuss the effect of polysulfide polymers, polyesters, and polyamide resins on epoxy resin systems. Emphasis will be placed on the importance of the different modifiers and their effect on properties.

"Epoxy Resin Hardener Systems" will be discussed by Mr. George Firth of Applied Plastics. This paper will discuss the chemistry and cure of epoxy resins by various types of hardeners or curing agents.

John Delmonte of Furane Plastics will describe "High Temperature Anhydride Cures." This paper will dwell on the results obtained with anhydrides as curing agents for epoxy resins. Emphasis will be placed on high temperature properties of these systems.

Joseph Philipson will discuss "High Temperature Liquid Amine Hardeners." This paper will dwell on the preparation of eutectic mixtures of primary aromatic amines. The paper is illustrated with a large amount of physical data, heat distortion points, and results obtained on laminates made with various finishes on glass cloth.

"Dermatoses and Epoxy Systems" will be described by Mr. Elliot N. Dorman of the Ciba Company. This paper is based on medical investigations by Ciba in many European plants employing epoxy resin-amine hardener systems. Comparisons are made of the results in two types of plants, namely laminating and tooling shops compared to paint factories and manufacturers of epoxy resins. The paper outlines suitable precautions to be taken when handling these systems.

J. E. Carey of Shell Chemical Corporation will discuss the "Thermal Expansion of Filled Epoxy Resins." This paper lists properties of filled epoxy resins utilizing a wide range of inorganic fillers. Coefficient of expansion curves based on varying percentage of filler are included.

"Glass Fabric Finishes" will be described by Mr. Sam G. Salzinger of the Coast Manufacturing & Supply Company. This paper will discuss the problems of glass fabrics and their relationship to epoxy resins.

"Epoxy Laminate: Production Problems and Techniques" will be described by Mr. Guy Lively of Douglas Aircraft Company, Santa Monica. The paper will describe the problems and techniques developed over the past several years as a result of the integration of epoxy laminates into production at Douglas.

The next paper entitled "Epoxy Laminates from Pre-impregnated Reinforcements" will be described by Mr. Bruce Godard of the Bakelite Company. This paper will dwell on the problems involved in impregnating glass fabrics and the results obtained from such impregnated fabric when made into laminates and reinforced structures.

The last paper will be presented on the subject of "Epoxy Adhesives: Production Problems and Techniques." This paper will be presented by Mr. John R. Boetto of North American Aviation at Torrance. The paper will dwell on the production problems and techniques evolved over the past several years when utilizing epoxy adhesives in the manufacture of aircraft structures.

Mr. Russell M. Houghton of the Houghton Laboratories will give an after lunch talk on "Epoxy Resins, A Look into the Future." This paper will be in a lighter vein where Mr. Houghton will try to prognosticate "what will be" with Epoxy Resins.

Advance registration can be made by sending $5.00 to the Society of Plastic Engineers, Southern California Section, in care of Mr. Paul Erskine at 313 East Washington Boulevard, Los Angeles 15, California. The $5.00 registration fee includes lunch and a booklet containing the symposium papers.

A large registration is expected because of the interest in this subject in the Southern California area and throughout the country. Consequently, it is suggested that as many advance registrations as possible be made. The papers submitted are of especially high calibre and are profusely illustrated with technical tables, graphs and curves which will make it a valuable addition to the libraries of those attending.

Kentuckiana

Nylon In Engineering

R. O. Carhart

The September meeting of the Kentuckiana Section of the SPE was held Wednesday evening, September 19, 1956, at Evansville College, Evansville, Indiana with 24 members and guests present. We were pleased to welcome the following guests and hope to see them back again: G. G. Price, Parke Woodworth, John Dockum, Watson Warriner, W. A. Purtzer, "Chap" Rust, Golden Kruse, and H. D. Arnold.

Following dinner and a brief business meeting, with President Ken Erwin presiding, an interesting and informative talk was given by Mr. W. C. Warriner of E. I. duPont de Nemours & Co. on "ZYTEL Nylon Resin —A Versatile Engineering Material." Mr. Warriner's talk was accompanied by numerous slides and charts and covered the properties of nylon as an engineering material, and considerations in designing with nylon. The useful properties which nylon has were discussed, some of which are as follows: (1) low specific gravity; (2) excellent wear and abrasion resistance; (3) excellent impact resistance; (4) excellent chemical resistance; (5) virtually unattacked by water below 150°F. (water is absorbed however) and; (6) self lubricating.

Also discussed by Mr. Warriner were some of the things which should be considered in designing parts of nylon. In general, these covered the effect of moisture and temperature on such properties as tensile strength, modulus of elasticity and dimensional stability.

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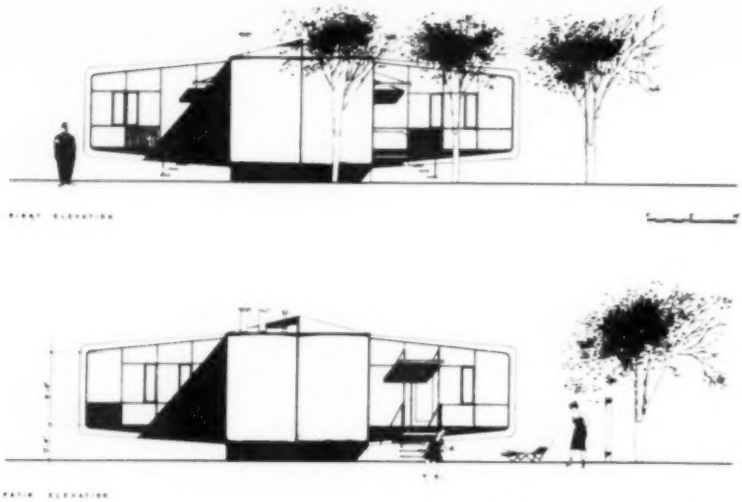

Architectural projection of the plastic "House of Tomorrow," designed by the Department of Architecture, M.I.T. in conjunction with Monsanto Chemical Co., Plastics Division.

Western New England

Expansion of Plastics Markets

C. P. O'Donnell

The evening of September 5th saw the end of the summer hiatus for the Western New England Section of the S.P.E. This first meeting of the 1956-1957 season was held in the Terrace Dining Room of the Bradley Field Administration Building. The after-dinner speaker, Mr. Ralph Hansen, Market Development Department Manager, Monsanto Chemical Company, Plastics Division, was introduced by Mr. Robert Moyer, who is responsible for the Monsanto Lustrex Styrene Technical Service Department. Mr. Hansen, who has a long history of sales experience with Monsanto, Dupont, L. Bamberger & Company and American Telephone & Telegraph Company, discussed the "Expansion of Plastics Markets Through Market Development" and the Monsanto "House of Tomorrow."

The speaker pointed out that in the introduction of new products and in the maintaining of an established product's sales position, proper marketing is of prime importance. This marketing concerns itself with all phases of the product itself and its actual market, including product color and design, cost, customer preferences and prejudices, and the general "climate" surrounding a product's sales area.

Here Mr. Hansen touched on the research, study and experimentation involved in just the development of product design. Not only color, and combinations of color, can be used to make an item more attractive to the consumer, but shape itself can quite often affect the sales curve. Modern designs today feature full, smooth and graceful lines—for example, the long, low home of today compared to the turn-of-the-century house of high dormers, tall spires, and "gingerbread" trim. In a recent design vs. safety survey conducted by the auto industry among prospective consumers, a choice was offered between safety and design. 70% indicated safety as their preference. However, when a follow-up survey checked actual auto sales, 70% of the buyers actually bought design rather than safety.

The speaker then went on to the new developments in various plastics, and how these enhanced plastics for the consumer. He discussed the large size and attractive items made of polyethylene, the appeal found in the safety of polyethylene washtubs for babies, and the triangular and trapazoid tile patterns for styrene which have expanded tile use beyond kitchen and bath. Also the decorative building and furniture applications for vinyls, polyesters, melamine, styrene and polyethylene, and the use of molded plastic parts for furniture, which has caught the interest of companies such as Sears Roebuck and Company, were pointed out.

The Monsanto Market Development Manager then gave an outline of the development of Monsanto's "House of Tomorrow," designed to feature the possibilities of plastics in building. An actual working prototype house is being constructed in Disneyland and will offer modular reinforced plastic units, cantilevered from a central core, with all permanent fixtures such as ducting, bath units, etc. formed in the modules. Architects and builders have evinced a strong and favorable interest in the house, which will also have a Kelvinator electronic kitchen, all types of American Telephone and Telegraph communication developments, and use an atomic reactor for heating and cooking.

The meeting concluded after a short question and answer period was held by Dr. Hansen.

Central Indiana

Basic Principles Of Color TV

C. R. Smith

Central Indiana's first meeting of the Fall season on Sept. 27th at the Warren Hotel in Indianapolis, was attended by a total of sixty guests and members.

The group enjoyed a non technical presentation of the basic principles of colored television by Mr. Wayne Bledsal and Mr. Cliff Burgett of R.C.A. Both of these gentlemen are closely associated with RCA's colored TV manufacturing facilities at their Indianapolis plant.

The basic differences between black and white and colored television were discussed as well as a comparison of the several methods of receiving colored television transmissions. A progress report on the advancements made on these sets in both quality and cost reductions, would indicate that they will enjoy a much broader market in the very near future.

Announcement was made of several changes in this Section's Officers and Directors as a result of some recent transfers and withdrawals. Mr. Gene Quear, Delco Remy Div. of General Motors Corp., Anderson, Indiana replaces Dave James as National Director. Mr. Walter E. Ellsworth, Industrial Mnfg. Corp., Indianapolis has been appointed to the Section's Board of Directors and will assume the Office of the Secretary, vacated by Bill Millholland. Mr. Harold Riley, Jr. will complete the unexpired term of Treasurer, also vacated by Bill Millholland.

Upper Midwest

Imagineering and the Future of Plastics

Russell B. Kirby

The opening dinner meeting of the 1956-1957 program was part of a two day **Introduction To Plastics** course sponsored by the Upper Midwest Section and given at the University of Minnesota Center for Continuation Study. Mr. Cort Platt, the section president, gave a brief preview of the Isocyanate Symposium to be held in Minneapolis on October 23 and then introduced Hiram McCann, Managing Editor of Modern Plastics.

Mr. McCann's address was nominally entitled **Imagineering.** The title though appropriate did little to describe the contents. Some rather startling facts were presented and equally eye opening predictions were made. Of interest was the fact that the production of plastics exceeded the production of non-ferrous metals in 1955 when the two were compared on a volumetric basis.

Mr. McCann pointed out certain factors which will increase total consumption of plastics in the next ten years, and factors which will increase per capita consumption.

If the plastics industry follows a normal growth it will still be expanding rapidly to keep pace with increases in population and the large rate of household formation expected around 1960. However, the abnormal growth of the plastics industry is expected to continue because of a large increase in per capita consumption. Significant factors in increasing per capita consumption are the probable favorable price trends of plastics versus other materials; new markets through new uses of existing plastics; new markets through better distribution and sales coverage (as is necessary, for example, in the do-it-yourself market); and new markets created by new and improved plastics.

Mr. McCann touched briefly on the major materials within the plastics industry and pointed out the general trends in each field. In particular the advances in formulation and processing technology were stressed. Formulation through copolymerization, betatailor properties to end uses is, according to Mr. McCann, an accelerator resin systems, etc. in order to ing trend and will result in major advances in most fields. He cited the effects of improved processing on the markets for some old standby plastics.

The effect of extrusion of sheet on the acrylics and the effect of vacuum forming and "skin" packaging on the cellulosics were given as examples. More progress was predicted of processing technology in the coming decade. Lower costs of bulk plastics through improved polymerization plants and processes; greater use of semi and fully automatic molding, particularly in the field of thermosetting compounds and laminates; perfection of methods to handle larger plastic pieces; and improvement of existing extrusion techniques coupled with mass production techniques in certain lines are expected to lower costs for finished plastic articles and consequently open new markets. Mr. McCann stressed the fact that today some new markets exist that are untouched because of a combination of deficiencies in production techniques and sales distribution. In citing these fields which are only waiting for exploitation Mr. McCann certainly ended his address with a mood of imagineering.

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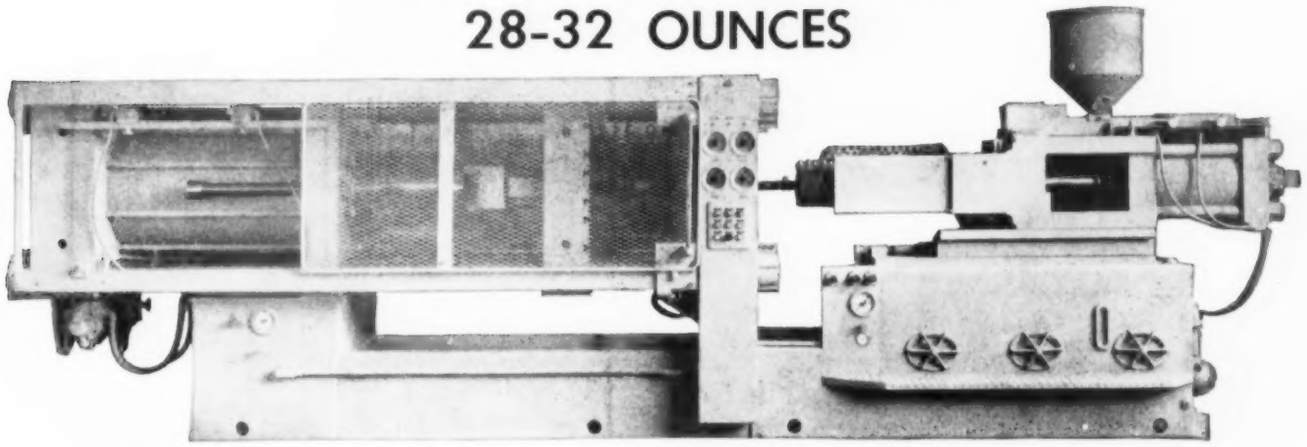

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New York

Tolerances and Shrinkages in Plastics

T. Dugan

"Tolerances and Shrinkages in Plastics" was the topic under discussion at the New York Section dinner meeting on September 19. Over 120 members and guests were in attendance at the Gotham Hotel in New York City for this, the first meeting of the fall season.

"A Molder and a Tool Designer View the Problem of Tolerances". This problem was covered dually, by C. W. Kleiderer, Penn Plastics, and E. J. Csaszar of Eagle Tool. The former felt that single-cavity mold was necessary for dimensional testing, though many companies would object to the additional expense. Tolerances are dependent both on the material in question, and the machines, since shape and size will affect shrinkages to varying degrees. Trial and error are the only methods for developing the perfect mold; however, a check of electrical controls often times uncovers minor difficulties. Mr. Csaszar stated that tool design was vital in molding to tolerances. He gave the following five reasons for molding imperfect parts: error in fabrication, miscalculation of shrinkage, heat distortion, mis-miter in multiple-cavity molds, and use of hobbings and castings.

W. G. Turnbull, Bell Telephone Labs., spoke on "An End-User Looks at Molded Plastics". He described Bell's program for determining the tolerances necessary for molded, threaded parts. The firm had encountered considerable difficulty with phone ends, where 2-14 mil differentials were obtained between threads. A rigid set of tolerances was established, based on practical need.

"Control of Molding Shrinkage of Thermoplastic Materials" was covered by Arnold M. Meyer, Bakelite Co., who pointed out that thermoplastics presented greater problems with respect to shrinkage than thermosets; the reason being their ready-formed molecular structure. The best approach to testing seems to be a single-material study, since conclusions may not apply to the field as a whole. In the case of polyethylene, orientation plays a very important role in past shrinkage. As molecular weight and melt viscosity increase, so does the degree of orientation and shrinkage. An increase in material temperature reduces shrinkage by decreasing those factors. Increased mold pressure, but not temperature, have similar effects.

"Control of Molding Shrinkage of Thermosetting Materials" was described in detail by Bakelite's Alfred J. Guzzetti, who emphasized the expenses involved in altering a mold. Thermal contraction, elastic recovery, and plastic deformation were defined. Molding variables were explained in terms of secondary effects: mold temperature, preform temperature, cure time, applied pressure, ejection time, and cooling rate. He illustrated his talk with a number of slides and graphs.

The New York Section welcomes the following new members, bringing the unofficial total to 586: David Hirsch, Monsanto Chemical Co.; Irwin H. Robinson, Robinson Plastics; Robert Shevett, Rainville Co.; Peter Hydrean, Bulova Watch Co.; Gustave C. Maassen, R. T. Vanderbilt Co.; David R. Hume, Crucible Steel Co. of America; Robert J. Patrick, Crucible Steel; Arthur M. Weinberg, G. M. Basford Co.; David M. Knott, Chas. Pfizer & Co.; Joseph J. Mele, Grumman Aircraft Co.; Kenneth Gross, American Molding Powder & Chemical Corp.; Jack Borsellino, Thiokol Chemical Corp.; Anthony F. Gurdo, Rome Air Development Center; James B. Sisson, St. Regis Paper Co.; Eric Mackey, Borden Co.; Edward A. Durbeck, International Business Machines Corp.; William F. Sporing, Catalin Corp. of America; Jesse Ross, Ross Industrial Services; Joseph Sucher, Emsig Mfg. Co.; J. Franklin Perrine, Consulting Engineer; William C. Roher, Jr., Spencer Chemical Co.; William G. Young, Francis Earle Labs.; Richard E. Saylor, Koppers Co.; Albert Frederico, Jr., Koppers Co.; Paul Marcus, Damac Tool Co.; Leonard Bloom, Ideal Toy Corp.; Frederick Gartner, Gartner Plastics Corp.; Jack Sherman, Plicose Mfg. Corp.; Maurice Martin, Bassons Industries Corp.; Sol Halpern, HIS Tool & Mold Corp.; J. E. Nester, Bigelow-Sanford; George Smolka, Metal & Thermit Co.; James R. Myles, I.C.I., Ltd.; Robert W. Sherman, Bakelite Co.; Nick George, RC Molding Co.; Armand Marcucilli, Merit Creations, Inc.; Frederick W. Schneble, Jr., Photocircuits Corp.; Clarence W. White, Jr., Eastman Chemical Products, Inc.; Adrian W. Whited, Dow Chemical Co.; Angelo Cuozzo, A. M. Cuozzo Co.; Peter M. Miale, Astor Tool & Die Co.; Dennis Johnson, Monsanto Chemical Co.; Gustave L. Bonwitt, Research Consultant; Marcus White, St. Regis Paper Co.; George Shluger, Continental Extrusion Corp.; James H. Versteeg, Bakelite Co.; Adolph Dellheim, Excel Plastic Mfg. Corp.; John Maffia, Toy Industries, Inc.; Edward F. Jones, Toy Trix Corp.; Murray Schotland, Gibson - Thomsen Co.,

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Regal Plastics Expands

J. S. Kivett, President, Regal Plastic Company, Kansas City, Missouri, announces the establishment of a Detroit, Michigan, Sales-Engineering office. H. H. Jones and H. M. Shields, both graduate engineers, will be the sales representatives in this new area.

R. F. Carlson, Jr. has also been appointed resident sales representative in St. Louis, Missouri.

Foster-Grant Appoints Peter Castel

Peter A. Castel has been named director of New Products Development of the Foster Grant Company, Leominster, Mass, pioneer and leading plastics molder, as part of the company's continuing expansion program. The announcement was made by Joseph C. Foster, president.

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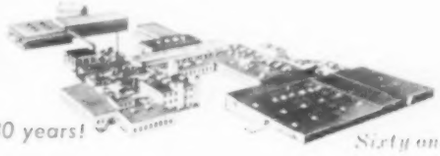

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Book reviews

The Condensed Chemical Dictionary — Fifth Edition.

Published 1956 by Reinhold Publishing Corp., New York Chapman & Hall, Ltd., London. 1,200 double-column pages, $12.50.

This dictionary, formerly directed by Francis M. Turner, first appeared in 1919 and had its 760-page Fourth Edition in 1950. Since then, it has been completely revised and enlarged by Arthur and Elizabeth Rose of State College, Pa. It is difficult to imagine more factual information on chemicals and related materials crammed into one handy volume than has been done in this book. It contains over 30,000 individual subject entries in a straight alphabetical arrangement. Quality of paper and print are excellent, and the entire volume is alphabetically thumb-indexed.

Each entry gives a short but clear definition of the substance and lists its chemical formula, properties, constants, derivation, grades available, uses, containers and shipping regulations. Depending on the type of entry, additional information is tabulated on habitat, occurrence, method of purification, compatibility with other substances, viscosity, chief constituents, color range etc. Special cautions, such as degree of fire hazard or toxicity, are also indicated where applicable.

Among the many subjects, directly or indirectly connected with chemistry, which are covered in this dictionary and are far too numerous to list here, the following may be of particular interest to the Plastics Engineer: Plastic materials and rubber, plasticizers, cellulose derivatives, petrochemicals, adhesives, solvents and pigments. Trade names of chemicals and allied products have been given considerable space in this edition, and they are key-indexed to a list of 355 manufacturers. Abbreviations and "alphabet soup" names are included and identified in the listings.

Numerous cross-references among the entries of this dictionary should be of great help in clarifying the confusion often resulting from existing chemical terminology. To sum up, and quoting from the fly-leaf, this is indeed "A reference volume for all requiring quick access to essential data regarding chemicals and other substances used in manufacturing and research, and to terms in general use in chemistry and the process industries."

Fred R. Homburger

Manpower and Education

Issued by the Educational Policies Commission of the National Educational Association of the U.S., and the American Association of School Administrators, 1201 Sixteenth St. N.W., Washington 6, D.C. 128 pages, $1.25 paper-bound, $1.75 cloth bound.

If you are interested in the supply of trained manpower, or want to understand the problems to be faced on all levels of our school system, this little book will help put things in focus with its wealth of factual data and its discussion of educational problems and policies as related to the development of professional and technically trained manpower. **Theobald Wurmer**

Polyesters and Their Applications

By Johan Bjorksten, Henry Tovey, Betty Harker and James Henning (Bjorksten Laboratories); 576 pages, published 1956 by Reinhold Publishing Company, price $10.00

"Polyesters and Their Applications" is a well organized summary of the polyester field, with emphasis on polyesters of the unsaturated type. It is appropriately dedicated to the Classification Group in the U. S. Patent Office. It contains well-written chapters on Theoretical Considerations, Unsaturated Polyesters, Saturated Polyesters, Testing, and Health Hazards. However, the major and perhaps most useful portion of the book consists of an annotated bibliography of the literature on polyesters published up to June 1, 1954, covering patents, commercial technical literature and published articles. Over 3000 references conveniently classified into sections on Raw Materials, Theoretical Considerations, Resin Manufacture, Tailor-making Polyesters, Catalysis and Inhibition, Fillers and Reinforcements, Shaping, Finishing, Final Products and Testing are included. The reference sections cover not only unsaturated polyesters, but also linear polyesters forming fibers, films, and (by reaction with diisocyanates) foams. This convenient key to the literature on polyesters represents a valuable tool to the worker in this field.

In treating the subject in this comprehensive and essentially non-critical fashion, the authors on a few occasions have made unfortunate choices in their presentation, resulting in isolated statements which likely will be regarded as questionable or misleading by industry technologists. Among these are statements that ". . . most common polyesters contain 30% of styrene but need only 16% to become thermoset" (p. 14); that "The conventional way to store styrene is to dilute it with an inert low boiling solvent, add hydroquinone and keep under a nitrogen atmosphere" (p. 30); that "The trend in finishes (for glass fiber) undoubtedly will favor gas phase application to the virgin fiber as it is formed" (p. 87); and that "Propylene glycol will give water solubility (to polyesters) without the introduction of an undesirable oxygen bridge" (p. 167). The authors also chose to discuss the polyester formed from a bisphenolic glycol with fumaric or maleic acid in the section on fiber forming polyesters, whereas it obviously belonged in the unsaturated polyester section.

Errors and omissions in the books are few and unimportant. It was noted that the number of the Vincent reference on p. 12 was in error, and that "alkyl" instead of "alkyd" obviously was intended in reference 337, p. 291. On p. 302 "Emsig" was misspelled, "Bunnell" on p. 332, "Howald" on p. 338 and "accelerators" on p. 351. Inclusion of material on isocyanates in the sections on Health Hazards would have been helpful.

None of these minor criticisms detract significantly from the value of "Polyesters and Their Applications," which can be recommended without reservation to those interested in polyesters. Dr. Bjorksten and his collaborators have provided the plastics technologist with a broadly useful and readily usable approach to the extensive literature on the chemistry and technology of polyesters. In doing so, they have rendered a valuable service to the chemist or engineer in this field. It is to be hoped that they will indeed carry on with their avowed intention to publish supplements from time to time.

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Subsidiary of Union Oil Company of California

Brea is now forming a national Plastic Sales Department. We want aggressive, experienced men for Regional Sales Manager and Technical Service Manager positions. Build your future faster with substantial growth in a young and progressive company. Write us in detail about your experience and references. All inquiries will be treated confidentially and answered promptly. Interviews will be arranged at your convenience.

Write or phone: Brea Chemicals, Inc., 714 West Olympic Blvd., Los Angeles 15, California.

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We have openings for chemists and chemical engineers with or without experience for product development of epoxy resin compounds and converters and to explore new uses for these compounds in plastic tooling, encapsulating, adhesives, laminating, electrical applications, etc. For one of these openings we would prefer a chemical engineer with a good background in electrical engineering. If you are interested in the future of epoxies and want to become associated with the Plastics Technical Service Laboratory of the Company who has pioneered in this field, forward resume and availability for an interview to C. M. Jackson, Coordinator, Technical Div. Devoe & Raynolds Company, Inc. Box 328, Louisville 1, Kentucky.

MANCO

'TRU-CAST' Beryllium Copper Mold Components Have Everything You Need

- Long Life
- Fidelity of Detail
- High Impact Strength
- Close Dimensional Tolerances
- Trouble-Free Performance

These "built-in" advantages, plus quality guaranteed by over 40 years of Manco casting experience, go into every 'Tru-Cast' cavity and core —adding up to better, faster production at substantial cost savings.

Write, wire, or phone today to bring your production problems to Manco — a copy of the 48-page 'TRU-CAST' HANDBOOK will be sent to qualified firms upon request.

MANCO PRODUCTS, Inc.

2401 Schaefer Road, Melvindale, Mich.
Telephone: Detroit—WArwick 8-7411

Frankly SPEaking . . .

(Continued from page 52)

no problem in semantics existed in the first place." Economy of words is desirable, but never at the expense of meaning. Abruptness is as much to be abhorred as is verbosity. Make YOUR letter writing an Art, but never a chore, by putting yourself into the letter.

Yours for Better Living with Plastics

Wayne I. Pribble

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with Cyanamid Plastics and Resins

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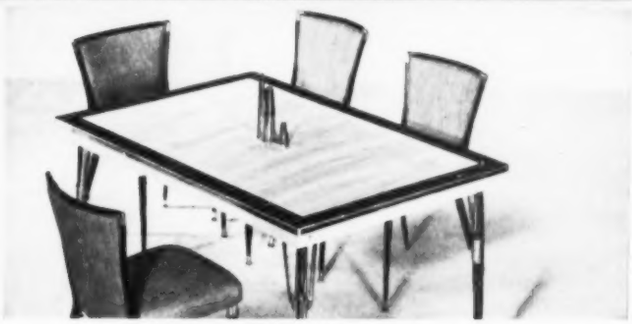

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Hi-fax is four times as rigid! Provides four to five times the rigidity of regular polyethylene.

Hi-fax is twice as strong! Has double the strength of conventional polyethylene.

Hi-fax has improved resistance to solvents and greases! Has a fluid permeability of only ⅓ that of regular polyethylene.

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